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Cincinnati

By N. P. AUBURN

Dean of University Administration, University of Cincinnati

Comparatively few cities can point to as long and consistent a record as a leading manufacturing and cultural center as can Cincinnati. Although the character of its industry and commerce has changed in important aspects over a period of a century or more, its adaptability in meeting the demands of changing conditions has kept it in pace with progress and is proving of special value in the war economy. At this writing, virtually all the 2,200 plants in the Cincinnati industrial area, representing some 250 industries, are geared to the victory effort. Contributing much to its reputation as a cultural center is the University of Cincinnati, which traces its origin back to the founding of one of its units, Cincinnati College, in 1819. This municipal University is internationally known as the home of the Cincinnati coöperative plan of technological education, the unique linking of industry with education to the end that practice can be learned simultaneously with theory.

Cincinnati is credited with being the world's largest producer of machine tools, soap, and playing cards. It has one of the largest plants in the world for the production of airplane motors. Other leading industries are foundry and machine shop products, laundry machinery, men's clothing, shoes, watches, radio receiving sets, printing and publishing, printing inks, electrical refrigerators, chemicals, drugs, and medicines, meat packing, automobile bodies and parts, pianos, office furniture, and pottery.

While most of these industries have been temporarily converted to war production, Cincinnatians confidently regard them as a tower of strength which holds the solution to the economic problems that will come with the post-war readjustment period.

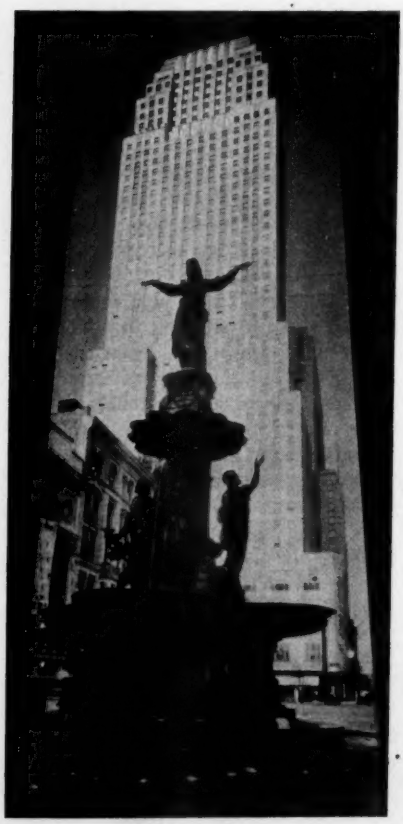
When the first settlers, coming down the Ohio River by flatboat, landed on the site of Cincinnati in November and December 1788, agriculture became the first industry. Trades and mechanical industries were not long in following. Fort Washington was built the following fall, and an early historian suggests the presence of mechanics in a reference to an "artificers' yard" adjoining the fort, in which were located workshops as well as homes for workers.

Printing was apparently the first organized mechanical industry in the new settlement. On November 9, 1793, William Maxwell established a newspaper, "The Centinel of the Northwestern Territory." Its motto was "Open to all parties, influenced by none"—suggesting that politics, too, had taken a foothold in the young community.

It was the first newspaper published north of the Ohio River. Edward Freeman took over the paper in 1796 and renamed it "Freeman's Journal."

He published it until 1800, when he moved to Chillicothe. In the meantime, Joseph Carpenter started a weekly, "The Western Spy and Hamilton Gazette," the first issue appearing on May 28, 1799.

Within that same decade, Cincinnati's commerce also had its inception. On January 11, 1794, two keel boats sailed from Cincinnati to Pittsburg, each scheduled to make a trip thereafter every four weeks. The perils of these voyages are suggested by the fact that each boat was protected against rifle and musket fire, and each carried small cannon—six pieces for the firing of one-pound balls. These precautions were against the menace of Indians on the banks of the Ohio.



TYLER DAVIDSON FOUNTAIN WITH CAREW TOWER IN BACKGROUND

A commentator in 1812 already foresaw the city's possibilities as an industrial center. He wrote: "Cincinnati contains about 400 dwellings, an elegant court house, a jail, three market houses, a land office for the sale of Congress lands, two printing offices issuing weekly gazettes, 30 mercantile stores, and the various branches of mechanism are carried on with spirit. Industry of every kind being duly encouraged by the citizens, it is likely to become a considerable manufacturing place."

It was in that year, towards the close of the War of 1812, that manufacturing became established on a firmer foundation. The Cincinnati Steam Mill came into being. It was devoted to the production of flour, cotton and woolen goods and flaxseed oil. This stimulated other enterprises, and two years later the city boasted, in addition to this undertaking, four cotton-spinning establishments, 91 wool-carding machines, a steam sawmill, and a sugar refinery.

The invention of the steam engine and the use of steam as motive power came to the attention of the people of Cincinnati as early as 1801, and out of this new knowledge came the creation of these early industries. An effort was launched at the time to organize a company to build steamboats, but nothing came of it. Ten years later, however, on October 27, 1811, interest in the project was revived when Nicholas J. Roosevelt brought his steamboat, the "Orleans," which he

CINCINNATI SKYLINE

LUNKEN AIRPORT

COLLEGE OF ENGINEERING AND COLLEGE AND SCHOOL OF APPLIED ARTS, UNIVERSITY OF CINCINNATI

had just built at Pittsburg, to Cincinnati, enroute to New Orleans. The whole town turned out to see it.

Under the inspiration of this event, Cincinnati was soon to become a great boat-building center. The "Vesta," first steamboat ever built in Cincinnati, was launched in 1816. It was a 100-ton craft and operated between Cincinnati and Louisville. Its steam engine later was used in Cincinnati's first steam-driven waterworks plant.

Steamboat building was a flourishing industry in Cincinnati for many years, until the ascendency of the railroad reduced river traffic to a subordinate place in commerce. However, it was the advent of the steamboat that soon made Cincinnati "the Queen City of the West." It became a great export and import center, the gateway to the South. The southern planter found that he could conveniently reach Cincinnati for his supplies, and, in turn, ship his cotton and other wares to Cincinnati for disposal in the North.

This helped to develop Cincinnati's meat packing industry, an enterprise that reached such proportions that the city became world-famous as "Porkopolis." Other industries grew out of this, too. Surplus corn that was not fed to the hogs was turned into whiskey and surplus fruit into brandy. Cincinnati also produced in this period, beer, porter, cheese, soap, candles, hemp, spun yarn, lumber, and furniture.

The city's expanding industries in the late 1820's and '30's included gunmaking, manufacture of hardware of all kinds, tanneries, rope-manufacturing, a sugar refinery, and wagon, coach, and carriage factories. The need for skilled mechanics prompted the organization of the Ohio Mechanics Institute in 1828—the first trade school of its kind west of the Alleghenies, still flourishing to meet present-day needs for skilled workers.

Mention of the Ohio Mechanics Institute is particularly appropriate in connection with Cincinnati industry, because one of its founders and ardent supporters through the subsequent years was Miles Greenwood, a noted pioneer in Cincinnati's machinery industry. Greenwood operated the Eagle Iron Works, and he is credited with having built the first steam fire engine.

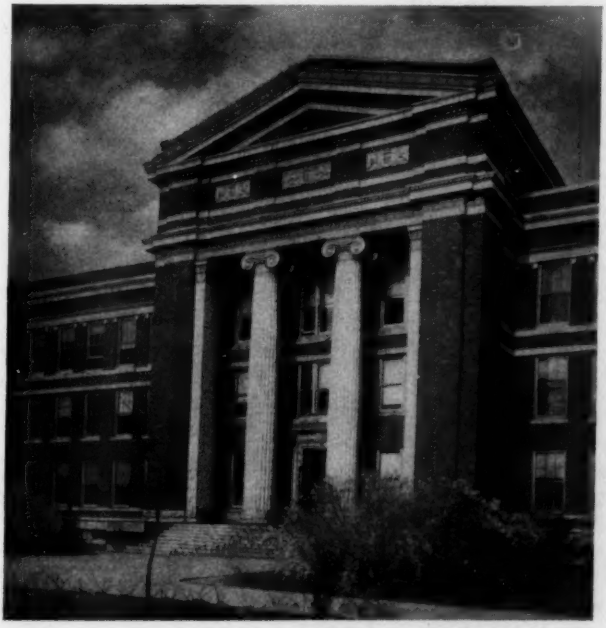
It should be noted that Cincinnati's early prosperity as a steamboat-building center played a leading role in developing its great machinery and machine tool industry; for steamboats required engines, boilers, pumps and other machinery; and plants sprang up to supply these needs. By 1841 Cincinnati had become the center of a big foundry and steam-engine building industry. The annual output was valued at more than $668,000; the output of the steamboat-building industry, $592,500; and that of the rolling mills, $394,000.

A century later, just before the outbreak of World War II, the value of Cincinnati machine tool products was set at approximately $41,000,000 a year. Wartime production has boosted this figure to fantastic proportions.

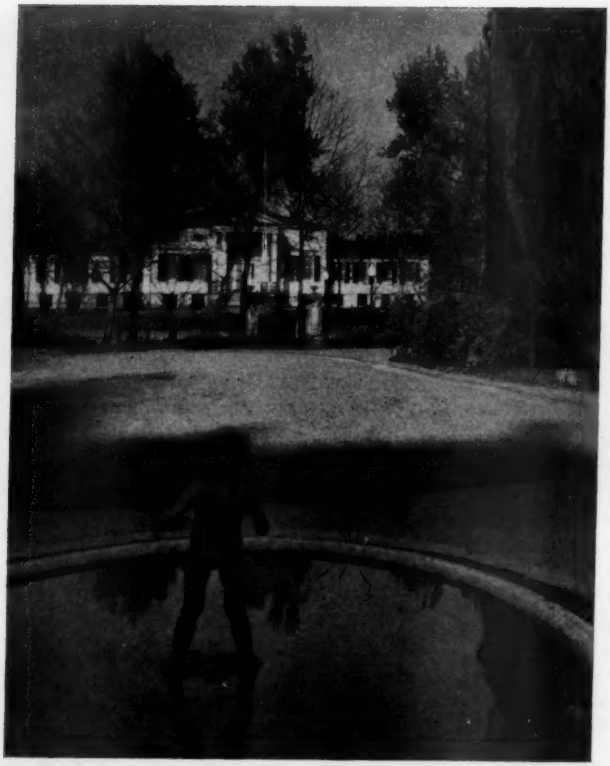
Cincinnati's industry and commerce were variously affected by the building of the Miami and Erie Canal and the advent of the railroads. The canal was opened between Cincinnati and Dayton in 1820, and completed to Toledo in 1845.

The first train ran from Cincinnati to Springfield, Ohio, on August 10, 1846. By 1848, the city had railroad connections with Lake Erie at San-

NEW STUDENT UNION BUILDING AT UNIVERSITY OF CINCINNATI



ENTRANCE TO BALDWIN HALL (COLLEGE OF ENGINEERING AND COMMERCE), UNIVERSITY OF CINCINNATI



dusky and by 1850 there was a connection with Columbus via Xenia.

The building of the Louisville and Nashville Railroad had diverted much of Cincinnati's southern trade to Louisville and presented a serious problem. This inspired a movement for a municipally-owned railroad, with the result that the Cincinnati Southern to Chattanooga was completed in 1880 at a cost of $30,000.000. It is today one of Cincinnati's greatest assets, and Cincinnati is believed to be the only city to own a major railroad system.

It was in 1906 that young Herman Schneider introduced the coöperative plan of engineering training at the University of Cincinnati. In normal years this University places its cooperative engineering, business administration and applied arts students for practical experience in 400 firms from Chicago and Detroit to Knoxville and Chattanooga, from St. Louis to New York City.

So successful is this Cincinnati plan that scores of technological colleges have adopted it. During the war years

it has seen renewed extension in many colleges as a means of permitting women students to contribute to the war effort while gaining their education.

It was this Cincinnati coöperative plan which brought to Dean Schneider of the University of Cincinnati the award of the Lamme Medal of the Society for the Promotion of Engineering Education in 1936 at its convention in Madison, Wisconsin. Dean Schneider died in March 1939. He has been succeeded as dean of the University's College of Engineering and Commerce and director of its School of Applied Arts by Dr. Robert C. Gowdy.

Soap-making has been one of Cincinnati's most important industries for a century or more. The largest of some half-dozen Cincinnati soap manufacturers is the Proctor and Gamble Company. It was in 1837 that William Proctor, who made candles, and James Gamble, who made soap in a modest sort of way, joined forces and became the Proctor and Gamble Company. They began operations in a small shed at Sixth and Main Streets on the site that is now occupied by a large office building that houses the company's general offices. Some $40,000,000 worth of products are shipped annually out of the Ivorydale plant alone, at Cincinnati; while its gross sales out of all its plants in various parts of the United States, Canada, and Cuba totalled in excess of $221,000,000 in 1939.

It is certain that there is hardly a household in America that does not come in contact with some Cincinnati product in its daily routine—be it soap, or school books, clothing or shoes, radios, pianos, watches, greeting cards, refrigerators, playing cards, chemicals or any one of a vast variety of other necessities and luxuries.

And guns, shells, airplanes, precision instruments, ammunition, surgical supplies and a thousand other items used on the fighting fronts—on the field, on the high seas, and in the air—bear the trade mark of Cincinnati industry.

The 52nd annual meeting, S.P.E.E., will be held in Cincinnati, June 22–25, 1944.

Enrollment of Undergraduate Civilian Engineering Students, as of October 4, 1943

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Totals	No. of First Degrees Conferred During the Academic Year 1942–43
Aeronautical	1,260	518	397	498	27	9	203	2,912	849
Agricultural	48	11	16	18	—	1	—	94	68
Architectural	131	100	61	92	7	2	—	393	180
Ceramic	38	24	25	51	—	21	—	159	64
Chemical	2,290	1,900	1,423	1,761	119	57	619	8,169	2,712
Civil	1,672	1,031	794	945	66	99	334	4,954	1,758
Electrical	2,057	1,587	1,318	1,710	87	46	794	7,599	2,410
General	1,150	382	237	76	—	14	108	1,967	232
Industrial	131	92	91	169	1	7	59	550	490
Mechanical	2,989	2,356	2,047	2,393	164	69	1,166	11,184	4,361
Metallurgical	96	155	187	289	10	8	134	879	511
Mining	73	68	84	127	7	5	1	365	280
Naval Arch. & Marine	172	123	134	68	—	—	—	497	169
Petroleum	191	79	71	80	—	3	—	424	397
Sanitary	4	5	6	10	—	—	—	27	16
Unclassified	5,569	727	184	140	5	781	1,857	9,214	247
Totals, 151 Schools	17,871	9,158	7,075	8,427	493	1,124	5,288	49,436	14,714

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Enrollment* in 1940–42	Totals 1943–44	No. of First Degrees Conferred During the Academic Year 1942–43
Alaska	6	1	2	1	—	1	—	122	11	—
Akron	44	6	3	13	8	—	—	278	74	41
Ala. Poly	213	81	55	124	—	5	—	1,278	478	209
Ala. Uni	105	51	65	89	—	—	40	933	350	169
Alfred	25	5	14	19	—	—	—	228	63	—
Arizona	56	22	13	16	—	—	9	383	116	45
Arkansas	—	—	—	—	—	—	—	332	—	—
Bradley	27	10	2	3	—	—	—	109	42	8
Brooklyn	87	114	76	112	—	2	1078	1,872	1469	139
Brown	150	30	33	27	—	—	—	171	240	—
Bucknell	45	13	17	23	—	—	—	261	98	44
Calif. Tech	75	24	16	49	—	—	—	542	164	99
Calif. Uni	167	76	80	138	—	—	—	1,876	461	397
Calif. Uni. So	67	31	43	51	—	55	110	756	357	117
Carnegie	171	152	87	75	—	1	323	2,010	809	265
Case	150	84	88	118	—	20	424	1,706	884	182
Catholic	34	12	21	29	—	—	—	268	96	43
Cincinnati	190	53	13	26	2	—	176	1,601	460	191
Citadel	105	46	—	3	—	—	—	213	154	32
Clarkson	56	74	33	38	—	—	—	510	201	104
Clemson	337	98	32	17	—	1	—	880	485	168
Colo. Mines	51	53	59	50	—	—	—	773	213	120
Colo. State	16	16	11	12	—	—	—	294	55	21
Colo. Uni	84	49	28	78	—	—	—	867	239	130
Columbia	100	55	34	70	—	12	—	585	271	70
Connecticut	78	33	23	25	—	1	—	230	160	35
Cooper	42	57	59	45	—	—	341	1,340	544	148
Cornell	233	140	74	98	30	1	—	1,350	576	195

* Antedating Selective Service.

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

* Antedating Selective Service.

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Enrollment* in 1940–42	Totals 1943–44	No. of First Degrees Conferred During the Academic Year 1942–43
Dayton	27	26	4	10	—	3	—	316	70	—
Delaware	33	13	9	8	—	1	—	226	64	31
Denver	45	14	14	12	—	—	—	152	91	17
Detroit	117	50	24	56	61	28	—	856	336	84
Drexel	234	93	40	129	—	2	—	880	510	105
Duke	37	19	20	31	—	—	—	234	107	30
Fenn	21	14	2	11	22	34	—	975	322	—
Florida	—	110	29	29	—	—	—	478	168	—
Geo. Wash	131	47	37	35	—	118	—	498	368	38
Ga. Tech	307	131	98	162	—	1	—	2,198	699	157
Gonzaga	—	8	—	15	—	—	—	152	23	12
Harvard	—	17	11	13	—	—	—	110	41	51
Haverford	8	3	1	—	—	—	—	—	12	—
Hawaii	58	25	7	5	—	26	—	132	121	2
Howard	47	11	10	3	—	1	—	54	72	9
Idaho	47	8	26	35	—	—	—	409	116	60
Ill. Tech	330	244	158	235	—	179	533	4,087	1,679	347
Illinois U	218	93	138	147	—	—	—	2,290	596	—
Iowa St. Coll	261	101	161	176	—	2	—	1,956	701	347
Iowa Univ	61	21	30	33	—	—	—	480	145	99
Johns Hopkins	64	50	40	34	—	7	340	1,696	535	77
Kansas St. Coll	95	31	35	97	—	—	—	1,047	258	143
Kansas Uni	130	37	42	65	—	—	—	649	274	95
Kentucky	60	19	11	16	—	1	—	429	107	57

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Enrollment* in 1940–42	Totals 1943–44	No. of First Degrees Conferred During the Academic Year 1942–43
Lafayette	32	37	30	47	—	—	—	332	146	61
Lehigh	151	91	72	89	—	—	—	1,040	403	220
La. Poly	86	37	39	32	—	—	—	—	194	48
La. So. W	72	25	17	15	—	—	—	236	129	—
Louisiana U	200	97	64	44	—	—	—	1,179	405	155
Louisville	45	39	28	52	—	—	—	324	164	50
Maine	101	39	32	49	—	3	—	611	224	98
Manhattan	80	48	25	34	—	—	—	307	187	45
Marquette	82	49	44	66	—	13	—	613	254	—
Maryland	131	73	39	44	—	5	—	597	292	121
Man. Inst. Tech	493	182	117	260	—	—	—	2,050	1,052	408
Mich. Mines	52	33	20	22	—	—	—	772	127	—
Mich. St. Coll	108	59	70	39	—	—	—	958	276	166
Mich. Univ	173	184	181	228	—	4	—	2,052	770	458
Minnesota	228	163	176	269	—	—	513	2,091	1,349	355
Miss. St. Coll	150	21	21	17	—	1	—	639	210	88
Miss. U	18	4	6	3	—	1	—	71	32	25
Mo. Mines	123	83	76	142	—	—	—	870	424	188
Missouri, U	91	29	34	50	—	—	—	622	204	107
Mont. Mines	6	2	13	7	—	1	—	475	29	34
Mont. St. Coll	32	12	16	35	—	—	—	290	95	69
Nevada	19	6	5	5	—	4	—	221	39	38
Nebraska	171	32	36	49	—	—	—	781	288	70
Newark	187	116	51	66	—	144	—	705	564	165
New Hampshire	69	24	8	34	—	3	—	390	138	89
N. Mex. A. & M	10	5	4	3	—	—	—	182	22	18
N. Mex. Mines	5	2	1	6	—	—	—	141	14	—
N. Mex. Uni	39	4	12	21	—	2	—	251	78	32

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

										No. of

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Enrollment* in 1940–42	Totals 1943–44	No. of First Degrees Conferred During the Academic Year 1942–43
New York City Coll.	991	376	400	388	—	248	524	3,278	2,927	258
New York Uni.	252	129	79	114	—	—	540	2,193	1,114	310
N. Car. St. Coll.	399	136	87	102	—	—	—	1,322	724	135
N. Dak. St. Coll.	36	7	10	13	—	—	—	326	66	—
N. Dak. Uni.	14	3	6	6	—	21	—	272	50	32
Northeastern	459	221	208	141	165	5	—	1,483	1,199	180
Northwestern	171	94	20	41	40	1	—	398	367	12
Norwich	Operating on War Department College Training Program only.							228	—	—
Notre Dame	124	42	37	67	—	—	—	529	270	—
Ohio No. Uni.	4	2	6	14	—	3	—	157	29	25
Ohio St. Univ.	304	129	126	129	—	—	15	1,800	703	291
Ohio Uni.	—	—	—	—	—	—	—	242	—	—
Okla. A. & M.	119	29	21	31	1	—	—	1,220	201	106
Okla. Uni.	168	45	50	56	—	—	—	1,551	319	163
Oregon	125	27	29	35	—	—	—	961	216	134
Pa. St. Coll.	191	163	122	266	—	—	—	1,718	742	323
Pa. Uni.	66	42	42	—	—	—	—	434	150	62
Pittsburgh	125	95	51	58	—	5	—	1,285	334	318
Porto Rico	—	—	—	—	—	—	—	313	—	—
Pratt	70	33	62	95	—	1	—	558	261	101
Princeton	65	37	49	21	—	1	—	404	173	147
Purdue	561	287	121	154	—	2	—	3,487	1,125	650
Rensselaer	210	56	42	98	—	91	—	1,260	497	206
Rhode Island	45	15	23	7	—	—	—	321	90	—
Rice	80	42	31	26	—	—	—	534	179	92
Rochester	23	17	25	2	—	1	—	172	68	62
Rose	29	14	32	23	—	—	—	283	98	97
Rutgers	87	37	26	23	—	5	—	250	178	38

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Enrollment* in 1940–42	Totals 1943–44	No. of First Degrees Conferred During the Academic Year 1942–43
Santa Clara	21	5	2	9	—	—	—	82	37	13
So. Car. Uni.	40	14	13	11	—	—	—	204	78	—
S. Dak. St. Coll.	22	9	12	12	—	—	—	230	55	27
S. Dak. Mines	16	46	42	37	—	—	—	311	141	71
So. Meth.	51	36	20	15	—	—	—	196	122	25
Stanford	—	—	—	—	—	—	—	417	—	—
Stevens	62	120	76	23	—	—	—	620	281	—
Swarthmore	20	21	10	6	—	—	—	73	57	20
Syracuse	95	80	34	65	—	4	—	438	278	—
Tennessee	65	48	49	78	—	—	—	738	240	99
Tenn. Poly.	22	7	2	10	—	—	—	178	41	4
Texas A. & I.	—	—	—	—	—	—	—	197	—	—
Texas A. & M	832	199	125	32	—	14	—	3,101	1,202	292
Texas Mines	—	—	—	—	—	—	—	—	—	—
Texas Tech	203	50	43	58	—	—	—	739	357	77
Texas Uni.	438	155	123	130	—	—	—	1,476	846	192
Thayer	20	6	2	4	—	—	—	23	32	18
Toledo	80	20	16	10	—	2	108	584	236	56
Tufts	38	29	23	64	—	—	—	394	154	43
Tulane	142	41	30	29	—	—	—	371	242	60
Tulsa	74	27	15	11	—	19	—	214	146	26
U. S. Coast Guard	150	109	97	—	—	—	—	261	356	82
Union	37	18	7	13	—	—	—	164	75	13
Utah Agr.	24	4	4	14	—	—	—	212	46	47
Utah Uni.	161	91	112	65	—	—	—	515	429	60
Vanderbilt	57	26	15	19	—	—	—	232	117	46
Vermont	23	7	—	7	—	—	—	133	37	—
Villanova	76	32	22	44	—	—	—	242	174	53
Va. Mil.	88	17	5	2	—	—	—	381	112	64
Va. Poly.	232	104	119	67	—	—	—	1,695	522	258

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Enrollment* in 1940–42	Totals 1943–44	No. of First Degrees Conferred During the Academic Year 1942–43
Washington	104	46	39	31	—	—	—	220	220	31
Washington U.	104	46	39	31	—	—	—	220	220	31
Wash. & Jeff.	15	6	4	3	—	—	—	28	28	3
Wash. & Lee	15	6	4	3	—	—	—	28	28	3
Wash. State	104	46	39	31	—	—	—	220	220	31
Wayne	104	46	39	31	—	—	—	220	220	31
Webb Inst.	15	6	4	3	—	—	—	28	28	3
Wentworth	15	6	4	3	—	—	—	28	28	3
West Va.	104	46	39	31	—	—	—	220	220	31
West Va. Tech	104	46	39	31	—	—	—	220	220	31
Western Res.	104	46	39	31	—	—	—	220	220	31
Wichita	104	46	39	31	—	—	—	220	220	31
Widener	15	6	4	3	—	—	—	28	28	3
Wilkes	15	6	4	3	—	—	—	28	28	3
Worcester	104	46	39	31	—	—	—	220	220	31
Wyoming	104	46	39	31	—	—	—	220	220	31
Yale	15	6	4	3	—	—	—	28	28	3
Totals	15,000	10,000	8,000	6,000	1,000	1,000	1,000	42,000	42,000	6,000

Va. Mil.	88	17	5	2	—	—	—	381	112	64
Va. Poly.	232	104	119	67	—	—	—	1,695	522	258

Enrollment of Undergraduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Enrollment* in 1940–42	Totals 1943–44	No. of First Degrees Conferred During the Academic Year 1942–43
Virginia	39	17	18	23	—	—	—	249	97	48
Wash. (St. Louis)	130	84	33	8	—	7	—	377	262	—
Wash. Uni.	146	49	59	63	—	—	—	1,444	317	161
Wash. St. Coll.	68	11	18	27	—	—	—	629	124	93
Wash. & Jeff.	26	17	13	23	—	—	—	—	79	—
Wayne	112	44	37	37	—	6	—	655	236	46
Webb Inst.	—	2	2	2	—	—	—	63	6	14
W. Va. Uni.	64	39	26	52	—	4	—	508	185	61
Wisconsin	142	116	162	192	—	—	—	1,472	612	198
Worcester	76	79	64	72	—	—	—	605	291	108
Wyoming	44	15	11	14	—	—	—	359	84	47
Yale	—	33	33	42	—	—	—	239	108	116
Total 143 U. S. Schools	16,609	7,985	6,334	7,737	329	1,122	5,288	108,911	45,404	14,145
Canadian Schools										
Alberta	89	114	56	48	—	—	—	299	307	—
British Columbia	250	182	129	96	81	—	—	—	738	95
Ecole Poly.	82	85	55	47	44	—	—	293	313	33
McGill	165	115	78	94	1	2	—	—	455	101
Nova Scotia	—	—	—	36	33	—	—	57	69	29
Queen's	189	163	99	90	—	—	—	588	541	109
Saskatchewan	163	176	74	77	—	—	—	470	490	—
Toronto	324	338	250	202	5	—	—	—	1,119	202
Canadian (8)	1,262	1,173	741	690	164	2	—	1,707	4,032	569
United States (143)	16,609	7,985	6,334	7,737	329	1,122	5,288	108,911	45,404	14,145
Grand Total (151 schools)	17,871	9,158	7,075	8,427	493	1,124	5,288	110,618	49,436	14,714

Enrollment of Graduate Civilian Engineering Students, as of October 4, 1943

Engineering Courses	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Masters Degrees Conferred in 1942–43	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degree Conferred in 1942–43
Aeronautical	49	82	14	—	145	59	7	10	2	—	19	2
Agricultural	2	4	—	—	6	5	—	2	—	—	2	—
Architectural	2	2	—	—	4	7	—	—	—	—	—	—
Ceramic	3	9	—	—	12	7	2	2	—	—	4	3
Chemical	111	145	231	35	522	143	65	81	23	1	170	46
Civil	48	70	41	2	161	100	28	18	—	—	48	14
Electrical	67	84	326	3	480	70	15	11	24	3	53	7
Industrial	9	36	52	—	97	15	—	—	—	—	—	—
Mechanical	43	132	249	5	429	116	15	22	—	—	37	4
Metallurgical	13	27	116	—	156	31	13	22	—	—	35	7
Mining	11	3	—	—	14	13	—	2	—	—	2	—
Unclassified	49	88	140	—	277	79	17	7	—	—	24	4
Totals of 76 Institutions	407	682	1,169	45	2,303	645	162	177	49	4	392	87

Enrollment of Graduate Civilian Engineering Students, 1943–44—Continued

	Enrollment in Work for the Master's Degree	Enrollment in Work for th

Enrollment of Graduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Enrollment in Work for the Master's Degree							Enrollment in Work for th						
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Masters Degrees Conferred in 1942–43	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Doctors Degree Conferred in 1942–43
Alabama	1	—	—	—	5	1	1	—	—	—	—	—	—	—
Alfred	—	2	—	—	—	2	2	—	—	—	—	—	—	—
Arizona	—	1	—	1	8	2	2	—	—	—	—	—	—	—
Brooklyn	—	14	283	—	—	297	18	—	2	49	—	—	51	8
Calif. U. So.	—	6	—	—	25	6	—	—	—	—	—	—	—	—
Cal. Tech.	24	9	—	—	103	33	37	7	7	—	—	26	14	1
Calif. Uni.	9	11	—	—	113	20	4	1	1	—	—	—	2	2
Carnegie	8	6	56	—	113	70	6	1	6	—	—	9	7	3
Case	1	64	—	—	85	65	7	1	9	—	—	8	10	—
Catholic	—	5	—	—	10	5	—	—	—	—	—	—	—	—
Cincinnati	14	—	—	—	23	14	4	7	—	—	—	8	7	7
Colo. Mines	1	—	—	—	14	1	7	—	—	—	—	—	—	—
Colo. Uni.	2	—	—	—	56	2	8	—	—	—	—	—	—	—
Columbia	4	12	—	2	—	18	30	3	8	—	—	—	11	4
Connecticut	—	—	—	8	38	8	—	—	—	—	—	—	—	—
Cornell	5	9	—	—	23	14	12	7	12	—	—	19	19	3
Delaware	—	3	—	32	34	35	—	—	—	—	—	—	—	—
Florida	—	1	—	—	6	1	—	—	—	—	—	—	—	—
Ga. Tech.	—	3	—	—	26	3	4	—	—	—	—	—	—	—
Harvard	11	2	—	2	108	15	20	1	1	—	3	32	5	3
Idaho	—	6	—	—	—	6	1	—	—	—	—	—	—	—
Ill. Tech.	2	37	72	—	328	111	17	—	12	—	—	13	12	—
Illinois Uni.	7	8	—	—	—	15	8	2	11	—	—	—	13	3
Iowa St. Coll.	2	7	—	—	42	9	3	—	9	—	—	18	9	2
Iowa Uni.	2	2	—	—	31	4	2	—	—	—	—	14	—	4

Enrollment of Graduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Enrollment in Work for the Master's Degree							Enrollment in Work for the Doctor's Degree						
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Masters Degrees Conferred in 1942–43	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Doctors Degree Conferred in 1942–43
Johns Hopkins	3	8	—	—	22	11	—	17	2	—	—	29	19	1
Kansas St. Coll.	—	8	—	—	33	8	—	—	—	—	—	—	—	—
Kentucky	1	—	—	—	2	1	1	—	—	—	—	—	—	—
Lehigh	—	14	—	—	51	14	18	—	3	—	—	19	3	2
Louisiana	1	2	26	—	18	29	1	—	—	—	—	1	—	—
Louisville	5	—	15	—	30	20	2	—	—	—	—	—	—	—
Maine	—	2	—	—	12	2	1	—	—	—	—	—	—	—
M. I. T.	175	—	—	—	333	175	164	57	—	—	—	122	57	20
Mich. St. Coll.	—	3	—	—	19	3	1	—	2	—	—	—	2	—
Mich. Uni.	30	—	—	—	144	30	33	19	10	—	—	54	29	7
Minnesota	—	7	—	—	94	7	19	—	26	—	—	7	26	1
Mo. Mines	1	7	—	—	16	8	1	—	—	—	—	2	—	—
Mo. Uni.	—	1	—	—	25	1	1	—	—	—	—	—	—	—
Mont. Mines	2	—	—	—	16	2	2	—	—	—	—	—	—	—
Nebraska	1	2	—	—	6	3	2	—	—	—	—	1	—	—
Newark	—	—	62	—	104	62	—	—	—	—	—	—	—	—
New Hampshire	—	5	—	—	4	5	4	—	—	—	—	—	—	—
N. Y. City Coll.	—	—	—	—	—	—	2	—	—	—	—	—	—	—
New York Uni.	13	244	—	—	348	257	30	—	14	—	—	23	14	—
N. C. St. Coll.	1	2	—	—	23	3	1	—	—	—	—	—	—	—
Northwestern	—	—	40	—	30	40	—	—	—	—	—	—	—	—
Notre Dame	—	2	—	—	5	2	1	—	3	—	—	—	3	—

Enrollment of Graduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Enrollment in Work for the Master's Degree							Enrollment in Work for the Doctor's Degree						
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Masters Degrees Conferred in 1942–43	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Doctors Degree Conferred in 1942–43
Ohio State	1	2	—	—	19	3	1	—	—	—	—	—	—	—
Ohio Uni.	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Oklahoma	1	1	—	—	3	2	1	—	—	—	—	—	—	—
Oregon St. Coll.	1	1	—	—	4	2	1	—	—	—	—	—	—	—
Penn. St. Coll.	1	1	—	—	4	2	1	—	—	—	—	—	—	—
Pittsburgh	1	1	1	—	3	3	1	—	—	—	—	—	—	—
Polytechnic	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Princeton	1	—	—	—	2	1	1	—	—	—	—	—	—	—
Purdue	1	1	—	—	3	2	1	—	—	—	—	—	—	—
Rensselaer	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Rice Inst.	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Rochester	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Rutgers	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Stanford	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Stevens Inst.	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Syracuse	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Tennessee	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Texas	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Tulane	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Utah	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Vanderbilt	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Virginia	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Washington	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Wash. St. Coll.	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Wash. U.	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Wisconsin	1	1	—	—	2	2	1	—	—	—	—	—	—	—
Yale	1	1	—	—	2	2	1	—	—	—	—	—	—	—

Engineering Courses	Enrollment in Work for the Master's Degree							Enrollment in Work for the Doctor's Degree						
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Masters Degrees Conferred in 1942–43	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Doctors Degree Conferred in 1942–43
Notre Dame	—	2	—	—	3	2	1	—	3	—	—	—	3	—

Enrollment of Graduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Enrollment in Work for the Master's Degree							Enrollment in Work for the Doctor's Degree						
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Masters Degrees Conferred in 1942–43	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Doctors Degree Conferred in 1942–43
Ohio State	3	—	—	—	40	3	8	5	7	—	—	25	12	3
Oklahoma Uni.	2	—	—	—	—	2	2	—	—	—	—	—	—	—
Oregon	1	—	—	—	12	1	1	—	—	—	—	—	—	—
Pa. Uni.	—	—	98	—	—	98	10	—	—	—	—	—	—	—
Pa. State	—	20	—	—	44	20	10	—	6	—	—	22	6	6
Pittsburgh	9	38	161	—	297	208	12	—	8	—	—	—	8	—
Princeton	11	—	—	—	15	11	9	—	—	—	—	—	—	—
Purdue	—	22	—	—	68	22	16	—	9	—	—	30	9	3
Rensselaer	—	5	—	—	25	5	4	—	—	—	—	—	—	—
Rochester	1	—	—	—	6	1	1	—	—	—	—	—	—	—
S. D. Mines	—	—	—	—	3	—	1	—	—	—	—	—	—	—
Stevens	—	—	356	—	337	356	—	—	—	—	—	—	—	—
Syracuse	—	3	—	—	—	3	—	—	—	—	—	—	—	—
Tennessee	—	5	—	—	41	5	4	—	—	—	—	—	—	—
Texas A. & M.	—	16	—	—	29	16	—	—	—	—	—	4	—	—
Texas Tech	—	2	—	—	2	2	—	—	—	—	—	—	—	—
Texas Uni.	9	6	—	—	48	15	10	7	5	—	—	17	12	5
Thayer	—	—	—	—	—	—	29	—	—	—	—	—	—	—
Tulsa	1	—	—	—	5	1	1	—	—	—	—	—	—	—
Utah Uni.	2	—	—	—	5	2	—	—	—	—	—	—	—	—
Va. Poly	2	7	—	—	51	9	12	—	—	—	1	2	1	1
Va. Uni.	—	1	—	—	2	1	—	—	—	—	—	—	—	—

Enrollment of Graduate Civilian Engineering Students, 1943–44—Continued

Engineering Courses	Enrollment in Work for the Master's Degree							Enrollment in Work for the Doctor's Degree						
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Masters Degrees Conferred in 1942–43	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others	Total 1940–41	Total 1943–44	Doctors Degree Conferred in 1942–43
Wash. St. Coll.	—	3	—	—	3	3	1	—	—	—	—	—	—	—
Wash. Uni.	—	13	—	—	—	13	9	—	—	—	—	—	—	—
Wisconsin	3	12	—	—	32	15	7	8	4	—	—	9	12	6
Worcester	1	6	—	—	15	7	3	—	—	—	—	—	—	—
Wyoming	—	—	—	—	1	—	1	—	—	—	—	—	—	—
Yale	9	—	—	—	27	9	4	13	—	—	—	33	13	2
Total U. S. Schools	380	674	1,169	45	1,981	2,268	637	159	177	—	4	547	389	87
Canadian Schools														
Alberta	—	3	—	—	—	3	—	—	—	—	—	—	—	—
Brit. Columbia	9	—	—	—	—	9	3	—	—	—	—	—	—	—
Ecole Poly.	3	—	—	—	1	3	—	—	—	—	—	—	—	—
McGill	1	1	—	—	11	2	2	—	—	—	—	—	—	—
Queen's	4	—	—	—	4	4	—	—	—	—	—	—	—	—
Saskatchewan	4	—	—	—	—	4	—	—	—	—	—	—	—	—
Toronto	6	4	—	—	—	10	3	3	—	—	—	—	3	—
Total Canadian Schools	27	8	—	—	16	35	8	3	—	—	—	—	3	—
Total U. S. Schools	380	674	1,169	45	1,981	2,268	637	159	177	49	4	547	389	87
Grand Total	407	682	1,169	45	1,997	2,303	645	162	177	49	4	547	392	87

Engineers' Responsibility in Civic Affairs*

By D. ROBERT YARNALL

Chief Engineer, Yarnall-Waring Co., Philadelphia, Pa.

Someone casually reminds us:

"A man is born a citizen and he may become an Engineer"

We who are members of American Society of Mechanical Engineers have had for years held before us in our Code of Ethics this advice:

"It is the duty of every Engineer to interest himself in the public welfare and to be ready to apply his special knowledge, skill, and training in the public behalf for the use and benefit of mankind."

Today, in war time, engineers are more fully engaged than in any time in our history. Their loyalty, ability and industry are universally recognized and generally commended. May we remind ourselves that the planning for their training and their performance was done years ago.

This afternoon I assume, as we consider together "Engineers and Civic Responsibilities," we are looking well ahead and beyond the war years. We all know that the stern realities of war probably will not allow experimentation with new educational technique as applied to the present going system. But just as we are at present engaged in post-war planning in the field of international relations as well as in the industrial and economic fields, so should we engineers be planning well ahead in our educational field, particularly as it relates to engineers' responsibility in civic affairs. We should remind ourselves that post-war planning must not be an escape from present responsibility. Yet our Government officials lead the way in urging us to look towards and plan for the Peace. The Secretary of State, in a notable address, has presented a striking outline of the structure of peace. He calls for swift and effective action at the close of the war to relieve human sufferings in war devastated countries. He hopes for the pursuit within nations of political liberty, economic security and social justice for all alike. He states the necessity of coöperation of all nations, including the United States, in establishing a genius to reduce armaments, to settle disputes by peaceful means, to reduce trade barriers and to provide equal access to raw materials. "No nation," said the Secretary, "will find this easy. Neither victory nor any form of post war settlement will of itself create a millennium. . . ." The vision, the resolution and the skill with which the conditions of peace will be established and developed after the war will be as much of a measure of man's capacity for freedom and progress as the fervor and determination which men show in winning the victory."

We in the engineering profession and particularly you in the S.P.E.E. con-

* Presented at the meeting of the Middle Atlantic Section, S. P. E. E., Haverford College, May 8, 1943.

cerned with the right development of engineering education, must be mindful of our responsibility for our part in this high calling.

Everyone expects engineers to design and build the sinews of war. Can they count with equal confidence upon them as citizens after the war not only to help beat swords into plowshares and spears into pruning hooks, but to help insure "that this nation under God shall have a new birth of freedom." What is freedom for us? How secure is it?

May I tell you a story of a personal experience in Germany? I had been sent to Germany during those days when the democratic Weimar Constitution was operative, in 1920, to plan for the distribution of American food to the undernourished children and mothers, and was at first assigned the job of organizing the feeding in the southern cities, with headquarters at Frankfurt am Main, including Stuttgart, Fortsheim, Carlsruhe, Mannheim, Heidelberg Darmstadt, and as far north as Kassel. In all of these districts I made intimate friends among those public-spirited Germans who were concerned with distribution of relief to children and mothers who suffered most by reason of the continued blockade which actually lasted long after the Armistice was signed in 1918.

Years later, but before Germany attacked Poland, I was again in Germany on another mission, and while there went down to Frankfurt to look up some of these old friends, to find out what was their present attitude of mind, particularly towards the political regime. An old doctor friend who had been particularly helpful in the Kinderspeisung days of 1920 asked me to spend Sunday afternoon with him and his wife and daughter in the Palm Garden. This was indeed welcome to me, as I thought I would be able to get from him, one of the local strong men of Frankfurt, the truth about Germany. We had a delightful afternoon under the trees listening to the music and talking about old times. I found that the doctor's wife was a violent Nazi; she could not understand why we "sensible Americans" did not understand the glorious new Germany which had come as a result of the National Socialist political victories. Their daughter, a girl of 18, a Hitler Jugend, was also an enthusiast for the new regime, saying that at last there was a future ahead for the young people of Germany and also a great future ahead for the Reich. At last Germany was taking her rightful place among the leading nations of the world. But all of this time I could not get an important word from the doctor. He questioned me a great deal about America and our political trends, about lynchings and kidnappings, as well as about the third term possibility; but not a word could I get from him about his judgment of Nazi Germany. The afternoon wore on and the musical program came to an end and one by one the occupants of the tables left the Garden. Finally we arose and as the mother and daughter walked on ahead down the aisle, the doctor took me by the arm and said, in a low voice, when he was assured that no one could hear: "One thing in America you must never lose—you must never lose the Letter to the Editor."

He knew that Germany had sold her birthright for a mess of pottage. They had gained Naziism with its "Ein Reich! Ein Volk! Ein Fuehrer!" but with this gain, freedom of speech, freedom of the press, freedom of religion had flown out the window.

How may we make more secure our freedom to write our "Letter to the Editor"?

May I repeat, "A man is born a citizen but he may become an Engineer." Are we who have chosen engineering endowed by birth with "good citizenship" characteristics? Alas, far from it. Somewhere along the line with the help of good environment and sound training there must be built in us a sense of concern, a social conscience, that will not be satisfied with personal success within the bounds of our profession, desirable as this is, but will drive us on and out *with other citizens*

(*a*) to carry our share of the burdens of the world's sufferings;

(*b*) to assume our constructive part in responsibility for good, wholesome government;

(*c*) to help in making secure those precious freedoms, among them the right without fear to write our Letter to the Editor.

In these last days, out of the clear blue, comes the *New York Times* disclosure on the apparent inadequacy of the teaching of American history as based on the survey of 7,000 freshmen in 36 universities. In time I have no doubt correctives will be applied to the criticized educational system which will better these percentages. I doubt, however, whether the engineering schools can count on secondary education to prepare freshmen in American history uniformly and thoroughly so as to make sure that in any test 75 per cent, at least, will answer that—Freedom of Speech, Freedom of the Press, Freedom of Religion, Trial by Jury, and Right of Assembly were five of the Freedoms guaranteed to the individual in the Bill of Rights.

Do you remember this warning in 1940, even before we were in the present war, by Hale Sutherland:

> "The time is ripe, however, for acceptance of our insistence that the Engineering Schools establish a humanistic core of study, substantial and dignified, extending through all the years of the present programs, a core of study which will acquaint the student with the organization and operation of all the major elements of our democracy, its social, economic and political aspects."

In 1940 were the engineering faculties of colleges and universities represented here this afternoon conscious of the inadequacy of freshman preparation in United States history and the fundamentals of our form of democracy? Perhaps these things were known, but you thought it should be the concern of other faculties. You were more than absorbed with the great task of getting over to recalcitrant freshman the math, chemistry, physics, descriptive geometry, kinematics and other subjects which are the backbone of our profession.

Someone always suggests that this broader subject matter should be presented in two years of college work preceding the four years of technological curricula. You know this proposal has not won acceptance. No, I am sure the answer is not to be found in a longer course.

All citizens must have responsibility for our democracy—engineers no more and no less than other citizens. We should all "highly resolve" never to leave the country in the hands of any but the most competent.

Experienced teachers tell us "that it is more or less difficult to make a group, either young or old, loyal to an abstract ideal which is not integrated with their greatest interest, and in the

case of engineers, through the vehicle of their own chosen profession."

Most young men are anxious and willing to contribute to the public good; naturally they would do best through the medium of their professional interest and training.

May I make a plea here and now for this core of study "substantial and dignified" extending through all the four years of our engineering courses —courses which will teach the essential elements of our democracy. I would have the standard of performance just as high in this core of study as in thermodynamics or calculus—and satisfactory completion just as essential for graduation.

May I make another plea to you very wise and experienced educators. Do not be indifferent to spiritual values in life, and *don't "cold shoulder" religion!*

Someone has said, "College young people are largely spiritual and religious illiterates, fatally ignorant in that all-important sphere of understanding which supplies *the binding element* in our complicated social order."

Madame Chiang Kai-shek said the other day, in one of her impressive speeches:

"We live in the Present
We dream of the Future
But we learn eternal truths from the Past."

With the press of many duties and responsibilities in college we are all conscious of the tendencies to crowd out spiritual and religious interests. Do you remember the experience of Brother Lawrence?

Resolving to devote himself to the service of God, he entered a monastery, but instead of spending his time in meditation and psalm-singing, he was sent to the kitchen—"being a dull and stupid fellow"—to cook for the rest of the community. He was greatly cast down; how could he practice the presence of God in a noisy room with people rushing about all shouting for different things?

Then came the answer—"Nothing is easier. I have but to turn the cake in the pan for the love of God."

He learned to offer up every ordinary humdrum duty as an act of worship, and thus the kitchen, not the cathedral, produced one of our finest Christian classics.

We engineers have all so worshipped the specialization complex and the bread and butter side of engineering that we have missed the great chance to help make secure the better world we are now all desperately demanding. We have ignored "this binding element" in our complicated social relationships, saying to ourselves and our friends, "Let us get on with our profession."

You decided to hold this conference at Haverford College. You are now on the campus of one of the important Quaker institutions of learning in America. One of the basic elements in the Quaker faith (and I believe this is also held by other faiths) is that conviction that there is that of God in every man—the belief in the sacredness of human personality—the belief in the direct revelation of God to man without intermediary—the Inner Light, as they call it. This religious element in life may be the guide to conscience, may be the driving force which will make men responsive to the demands of democracy.

We engineers have too often passed up religion as an emotional element in life, saying that it has little or no place

in engineering education—that this is the responsibility of others.

I am one of those engineers who believe with Richard Cabot, in his "What Men Live By"—a book much read during and after World War I—that there are four essential elements in the well-rounded life—Work, Play, Love, Worship.

No matter how perfectly we plan this core of study designed to build up a sense of civic responsibility in our engineering graduates, it will not be completely effective unless or until that Divine discontent within drives him out and beyond the narrow confines or boundaries of his profession, and compels him to use his engineering gifts to work with others for the good of the community of which he is a part.

I am not suggesting here that the engineering school, much less this "core of study," should assume the Sunday School function. On the other hand, I am sure our colleges and universities must assume more and more responsibility for religious instruction and not relegate it completely to the Student Y. M. C. A. and/or the more safely remote Divinity School.

Let us remember that citizenship responsibility has its vital roots deep within the Christian fundamental "Love thy neighbor as thyself."

Our material growth has been and continues to be rapid and far-reaching —our research laboratories pour forth advances in pure Science, new devices, new processes. For the years of Peace just ahead could we ever better afford to divert some of the precious time available to training Engineers for direct responsibility of citizenship?

What value has all this material progress if by reason of neglect or indifference we train Engineers who are unmindful of responsibilities of citizenship?

What doth it profit a nation if it gain the whole world and lose its own soul?

Post-War Planning for Engineering Education*

The Outlook for Engineering Education

War is a destructive process as is most evident on the field of battle. Its casualties, however, are not confined to the broken bodies of men in the field, to the twisted wreckage at the bottom of the sea, and to the blackened ruins of military objectives. It leaves its mark on everything with which it comes in contact. This war involves all of mankind and its institutions. As an institution which claims our major attention, engineering education has no special immunity from the scourge.

In institutions such as engineering schools the elements of destruction tend to be insidious. Unless we pause to take stock of our situation, we may even mistake retrogression for progress. We could compile quite a list of steps taken in the necessity of winning the war which must be retraced if we are merely to regain the position we had at the outset of the conflict. Let us name just a few. Our programs have been accelerated far beyond the point of maximum effectiveness in the ultimate training of our students. We are accepting younger students for training, which means that they do not possess the maturity of mind and the background of experience which heretofore we could take for granted. We have abandoned some of the time-tested methods of gauging progress, such as the final examination. Our curricula and courses are being gradually altered to adapt them to the subject matter of war-time effort as contrasted with our former predominant emphasis on mental training.

Let us not be misled by the promise of a bright new future to emerge from the conflict: of better automobiles, aeroplanes, and shower curtains to come out of the war-time laboratories; of improved institutions to grow out of the experience with war-time agencies; and of the four freedoms to be bestowed as the result of victories at arms. To be sure, these things may become possible—in fact, that is what we are fighting for—but they will become realities only if we are able to make them so. Defeat of our enemies is the first and most important step, but that alone will not attain our objective, regardless of the enthusiasm or tenacity with which it is pursued. To attain any worthwhile goal, we must first plan our work, and then we must work our plan.

Conditions at the End of the War

When we turn to post war planning, our first tendency is to say, "Let us win the war and then plan the peace. How can we make any reasonable post-war plans when we do not know when the war will end or what the state of affairs will be at that time?" The error in this point of view is obvious. When the war ends, the affairs of the world will not recess for a period of months while vast plans are made for the bright new future. Men will go right on working with the means at hand to

* Report to Dean A. A. Potter of Purdue University on February 5, 1943, by the Engineering Committee on Post-War Planning.

make a living; institutions will continue to the best of their abilities to improve the lot of mankind; and governments will proceed within whatever limitations are imposed upon them to promote the welfare of their constituents.

The success of these various efforts will depend largely then, as now, upon the degree to which they are directed toward the intended objectives. If no plans are made in advance, expediency of the moment will rule and we can expect a period of futility and frustration; if complete and intelligent long-range plans could be put into effect universally we might expect most of the ills of the world to vanish and see mankind emerge at last into the age of universal good will and well being. We know, as a matter of practical realism, that the actual state of affairs will be somewhere between these two extremes, and that the extent to which our objectives are realized will depend upon the degree to which we are able to formulate and carry out intelligent plans to secure them.

How can we make plans when we know so little about the period for which we are planning? First of all, let us take note that all plans inherently deal with the future and that at no period can the conditions of the future be looked upon as matters of certainty. We must always base our judgments for the future upon probabilities rather than strict matters of fact.

The chief difference between planning at this time and the planning we have done heretofore is that the uncertainties involved are greater. Sometimes it seems they are so great as to be almost equivalent to ignorance of the future, but a detailed study reveals that there are quite a few definite statements which can be made with a fair degree of certainty regarding the period following the war. Now, confining our attention to those matters which will have some bearing on engineering education at that time, we find the following statements reasonably well justified:

1. Immediately following the war, there will be a period of rapid change in which the country will try to turn away from war-time pursuits and go back as quickly as possible to the affairs of peace.

2. At the time the war ends, the engineering schools will have a considerably different kind of student body than that with which they entered the war, and it will be composed mainly of special groups preparing for specific war services.

3. The pre-war curricula and educational procedures will have been abandoned or greatly altered in the interests of the emergency.

4. The efforts to return to the long-range objectives of engineering education will be beset by many difficulties, especially by the pressure to proceed at once to meet the needs of the time.

5. There will be an unprecedented problem of demobilization of the vast armed forces of the country, and it may be assumed that the universities will be called upon to absorb large numbers of them, temporarily.

6. The emphasis on technical education will have been increased by the technical nature of the war.

7. Various special technical training projects such as the ESMWT will have developed extensively and may be expected to continue in some form.

8. The public will still be uninformed regarding the distinction between vocational and professional training; in fact, it seems likely that the operation of war-time specialist training pro-

grams will have heightened the misconceptions in this regard.

9. There will be a depletion of and consequently a great demand for consumer goods; a scarcity of productive facilities to supply these goods; and a dearth of technically trained men to convert the factories back to peace-time production.

10. The economic system will be in a condition of dislocation, characterized by the existence of large purchasing power in the form of government securities without an adequate supply of commodities to absorb it.

11. The foregoing conditions will tend to increase the demand for higher education, and may well result in swollen enrollments, drawn not only from the military forces, but also from the civilian population.

12. As a result of the economic dislocations as well as the dislocations in the public school system, the problem of non-homogeneity in the student bodies of engineering schools may be expected to be even more difficult than it has been heretofore.

13. The various staffs will have been depleted of their experienced teachers by the inroads of the war effort.

14. The opportunity for America to take the leadership in world affairs will present itself, and there will be suggestions that the training of engineers be altered to prepare them for this function.

15. There will be numerous changes in technical goods and services as a result of war developments, such as the extension of aerial navigation, the advances in chemical and metallurgical arts, and the obsolescence of consumer goods in general.

16. The emphasis on the social implications of the work of the engineer will be increased.

17. The importance of scientific management and labor relations will call for greater attention to these matters.

18. The university research programs will have received added impetus due to their contributions to the war effort.

19. There will be a vast bureaucracy in power at the end of the war, which will continue to make its influence felt in the affairs of the engineering schools.

20. The extension of government activities into technical fields will have created a demand for technical men trained specifically for government service.

21. An extensive program of public works is likely to appear at the close of the war, especially to bridge the gap between all-out war production and full scale peace-time production, which would enable those institutions with definite plans to improve their physical facilities.

This is a partial list. It mentions only part of the things in which we have some confidence at the present time. Also it refrains from mentioning other things of which we have no adequate basis of judgment, such as the length of the conflict, the degree of exhaustion at the end of the war, and the terms of the peace. All of these things, both in broad outline and in minute detail, will have their effects on our plans.

Clearly we are not justified in designing in blue-print fashion the details of each of the plans which is associated with these conditions. These are matters which must be decided at the proper time. If we can keep clearly in mind the broad outlines of the structural plans within which the individual

plans are to fit, the basic objectives which they are intended to attain, and the general policies to be followed in attaining them, then we will be in a position to formulate the details as parts of a coherent whole.

The Objective in Engineering Education

No plan can be very effective unless its aim is clearly understood. The individual person may be fairly successful in attaining a goal which he has not defined in words if his mental concept is clear, because he alone is concerned. On the other hand, an organization or institution must have a definitely stated aim, because large numbers of people are involved, and their efforts should all be directed in the same general direction. In fact, the aim must be restated over and over again, in as many ways as possible, because under the stress of daily occurrences we tend to deviate gradually from a fixed idea.

Just what is the aim in planning for engineering education? In a period of retrogression, the normal tendency is to try to regain lost ground. This is equivalent to defining our objective as the status quo at a given time, such as the beginning of the war. If at the time chosen we had attained the height of perfection, then this would be a proper goal. No time need be wasted on this point. We are all aware of many shortcomings in education, both now and heretofore. Furthermore, if we tacitly accept the former status quo as our objective, we shall inevitably arrive at a lower plane. Let us make every effort to avoid this pitfall.

In engineering education, we are fortunate in having an established, accepted, and well-stated objective. Thus we do not find it necessary to cast about in a time of stress for a new basis of planning. It is not necessary for us to make snap judgment of our major shortcomings, based on personal opinions. They have been thoroughly investigated on the basis of facts, in the true engineering method, at a time when such objective and orderly investigations could be thoroughly and adequately made. As stated by the Associate Director of these investigations, H. P. Hammond, there is "doubt whether any other more comprehensive, or more fruitful endeavor has ever been undertaken and carried through in any division of education, not even excepting medicine." They are the Investigations of Engineering Education conducted by The Society for the Promotion of Engineering Education, and their results are published as the "Report of the Investigation of Engineering Education," a bound volume which appeared in 1934. Here are to be found the factual statements of the shortcomings of engineering education before the war, and the accepted objectives of the plans. They are, in general, aims which are as valid for post-war planning as they were for pre-war planning. It remains only for us to adapt and reaffirm them, and to make our plans accordingly.

What are the specific aims indicated by this investigation, and what shortcomings does it reveal? Obviously a complete digest of the many reports involved which were merely summarized in the report of text-book size mentioned above is beyond the scope of our report. We can easily quote the keynotes. They are repeated again and again in different forms in the various studies which were made. They are perhaps best stated in the Final Report of the Chairman of the

Board of Investigation and Coordination, Charles F. Scott, as follows:

"An undergraduate course should equip wholesome and qualified youth with a basic acquaintance with science, familiarity with engineering methods, and an appreciation of social relations. These should be coördinated in time and in content and brought to a focus during the last year upon the student's major subject."

"Our engineering colleges are attempting too broad a field, handicapping their true function."

"Engineering education can cope with enlarging responsibility to society and increasing exactions of professional practice by enhancing its own distinctive qualities rather than adding unrelated elements from without. Emphasis on humanistic subjects for enriching the conception of engineering and its place in the social economy, a more connected and better grounding in engineering principles, and greater capacity for self-directed work may all be gained at the expense of unrelated studies and detailed training in technique. The latter should find place in post graduate and post scholastic courses." "For better engineering education we must look to better balanced curricula, better selection of students, better teachers, better methods, better subject matter and better advanced training rather than changes in educational organization."

This is not a superficial study which ends up by whitewashing the profession and advocating the status quo. Instead it concludes with words of wisdom based on facts. Furthermore, we recognize that the general policy advocated is precisely the one which we have been approaching for the past ten or fifteen years to make engineering education more effective. The important thing is to see to it that we do not deviate from major policies in this period of stress except to benefit by some apparent lessons of such a major catastrophe.

Three Basic Problems and Suggested Policies

How do these principles apply to our situation as it appears now and as it is likely to present itself at the end of the war? Let us consider briefly a few basic problems, and try to resolve them on the basis of the findings of this organization.

1. *The Curriculum and Course Content*

We see continual changes being made in our curricula and courses to adapt them to the emergency. These changes are necessary, but unfortunately most of them do not lead in the direction of our long-time aim.

There is the pressure to include all sorts of subject matter which seem important to special groups, such as courses on governmental procedures, cultural courses dealing with foreign lands where graduates may be called upon for service, specialized courses in economics to prepare our engineers to solve the economic ills of the world, and numerous technical courses dealing with such specializations as application of the new light metals to industry, the operation and maintenance of high-frequency communication equipment, and the application of various industrial processes. There is the pending program of crowding the technical courses into the first four terms, which is justified on the basis of military expediency, but is not in accord with the best practice of mental training as stated above. There is the general tendency in established courses to emphasize techniques at the expense of basic principles and methods of thinking.

The general trend of these changes

is to substitute the objectives of the technical institute for those of engineering education. In the interest of national safety, it is our duty to promote such changes as are needed at the moment; but we should be on the alert to evaluate their long-time effects, and we should be prepared to return as quickly as possible at the termination of the conflict to the policy stated by the Society for the Promotion of Engineering Education Committee "that the engineering curriculum must confine itself to presentation of the fundamentals, excluding topics that are not immediately essential."

2. *The Student Body*

The problem of adaptability of our students to their training is not new, but it is aggravated by present conditions. The Report states that "the basis upon which students make their educational choice is wanting in an understanding of what engineering is and the type of man suited to an engineering career." The current emphasis on war-time production merely heightens this misconception. In addition, we have the problem of students who are immature in training and experience coming to us as the result of accelerated programs. At the end of the war we shall undoubtedly be called upon to give engineering training to large numbers of service men whose experience and point of view will be widely divergent from that of their classmates.

Can such a diverse group be given satisfactory engineering training on common ground? That depends upon the standards which we try to maintain. If no special steps in selection are taken the standards must inevitably drop or the mortality rise. The most realistic step in the solution of this problem would seem to be the development of adequate admission requirements in forms such that they could be put into effect immediately when the opportunity presents itself. Quoting again from the Report of the Society for the Promotion of Engineering Education Committee, "it is a duty of engineering colleges to the profession to attract and admit qualified students, and to reject the undesirable and unfit." "Placement examinations are valid instruments for predicting scholastic achievement." We might add that if such examinations are to serve our purpose, they must be so constituted that they do not merely predict the ability of the prospective student to do work on the college level, but also indicate his adaptability to engineering training.

Regardless of the admission procedures which are applied, we will still have the problem of scholastic mortality. When we consider that heretofore only about forty per cent of the students who enrolled have succeeded in securing their engineering degrees at the end of the four years, we realize the enormous human waste involved. Current conditions will make it more severe unless adequate steps are taken to offset them.

Must we send all these students away with the brand of failure stamped upon them? Isn't there something we can do to salvage these important human resources and to send them out with their personal confidence restored? We think there is. The great majority of these students find themselves in trouble because they have been lured into a level of training beyond their aptitudes by the popular obsession for the college degree. Many of them visualize themselves doing the work of a technician when they enroll, with-

out realizing the distinction between the work of the technician and that of the engineer. Many are logical candidates for the type of training given in technical institutes, and if they could follow this training through to its conclusion in the school of their first choice, they would emerge with an attitude of success and satisfaction rather than one of failure and frustration.

The development of technical institutes of this nature must be done with caution. If such technical institutes are to be operated as mere salvage departments and given the status of a foster brother they are doomed to failure. If they are to be operated and administered by the engineering staff as part-time work, they will not be successful in presenting the desired vocational point of view. The studies show that such projects are successful if they train men in the technology of specific industries, such as instrument making, foundry practice, power plant operation, and so on. Such institutes center their instruction on the actual doing of the intermediate technical tasks of such specific industries, and as such they require the services of those men who have become thoroughly familiar, through industrial experience, with the industries which they represent.

With the development of extensive war training organizations operated in conjunction with the engineering schools, such as the ESMWT, we have made available an agency which can, with proper handling, be adapted to this need. Through its close contacts with war-time industry and its employment of industrial personnel as teachers it has acquired a knowledge of the needs of industry, and through its contact with thousands of students it has discovered their adaptabilities to these needs. For our purposes, however, it needs to concentrate its objectives on a few well-chosen industries, and we need to elevate its status to its true position of importance. If we make known, for instance, the fact that industry needs about three men trained in this way for every one having a college degree, and that the study showed that "earning power of a group of 1,000 two-year technical graduates is within about 5 per cent of the earnings of a large group of four-year college graduates," we may expect the reluctance of students to enter this type of training to vanish. Then if we provide suitable recognition to such students in the form of appropriate certificates of accomplishment, we may expect them to leave the university with a feeling of success, prepared to contribute to a genuine need of industry.

3. *The Teaching Staff*

Depletions in the regular teaching staffs as the result of the war effort will render our task more difficult, especially if there is a large increase in enrollment at the end of the war. If there is an influx of large numbers of students, rapid staff additions will be required. In the haste to fill vacancies, there will be great danger of loading up the staff with mediocre and even incompetent teachers. Every effort should be made to maintain an adequate staff of experienced teachers to serve as a nucleus around which the post-war staff can be built. When new members are recruited, care should be taken to see that they have not merely the proper educational training but also have those qualifications which enable them to carry the program of engineering education forward effectively.

Working the Plans

How shall these long term plans be put into effect? Obviously they cannot be worked out in detail and laid upon the shelf to be taken down and applied the instant victory is declared. Even though we find it necessary to give ground from time to time, it is nevertheless our duty to our students, to the profession, and to the public to see to it that we do not depart from our long-range objectives. If these are kept clearly in mind, the dislocations can be minimized, and we can be ready with preparations to take advantage of favorable conditions when they present themselves.

As expressed in a statement issued from the United States Office of Education: "Long-range educational planning can be sound and effective only if the daily contemporary educational program is an integral realization of the long-term plan. Long-term educational planning therefore will be realized only if the existing conditions and the contemporary program are moving toward the long-range objectives. Long-term planning must serve as the evaluative criteria for existing educational programs and stimulate the revamping of the contemporary program to the long-term goal."

The Committee:

L. E. Beck, *Chairman,*
D. S. Clark,
C. S. Cutshall,
H. F. Owen,
R. J. Raudebaugh,
G. P. Springer.

Aeronautical Relationships with the E. C. P. D.*

By HOWARD W. BARLOW

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In discussing the aeronautical relationships with the E. C. P. D., I will direct my remarks along the following channels:

(1) the relationship of the inspecting committee to the institution being examined for accrediting;
(2) the desirability of maintaining, in the post-war era, the present sound policy of the committee on engineering schools in the light of industry's experience with short term, intensive, terminal courses;
(3) maintaining the integrity and individuality of the aeronautical engineering curriculum as a professional curriculum and establishing our relationships with the E. C. P. D. on a more representative basis.

At the present time there are fourteen fully accredited curricula in aeronautical engineering and twenty-six options under accredited curricula. All of the latter are given as options under the Mechanical Engineering curricula.

One of the most important relationships existing between the E. C. P. D. and the institution applying for accrediting in aeronautical engineering is the composition of the Inspection Committee. I can say from personal experience as well as from having discussed the matter with other institutional representatives whose curricula have been accredited that, for the most part, these relationships have been extremely pleasant and profitable. However, there is one item which, if corrected, should result in an improvement in the accrediting procedure. In many instances none of the members of the examining committee has been sufficiently familiar with the field of aeronautical engineering and aeronautical engineering curricula.

There was no criticism of any inspection that was made in those instances with which I am familiar; the examination was fair, complete and constructive, but I wonder if the institution being examined did not fail to receive the benefit of additional constructive criticism which might have been offered had at least one member of the committee been intimately familiar with the aeronautical field.

In instances where the committee make-up does not include aeronautical engineers there is a great tendency to judge the curricula in a general sense, on the basis of the experience of, or existing curricula in, other schools; that is, "from second hand information," rather than on the basis of immediate personal knowledge.

One of the functions of the examining committee is to render constructive assistance to the institution apply-

* Presented at the Fiftieth Anniversary Meeting, S. P. E. E. (Aeronautical), Chicago, Ill., June 18–20, 1943.

ing for accrediting. In a great many cases, much good has come from the fact that this outside committee has been able to present to the administration of the institution detailed information and criticism which, when remedied, has resulted in extensive improvement in the curricula being accredited. The effectiveness of outside criticism from well-qualified and well-informed inspectors cannot be overestimated and should generally result in the improvement of situations which the department head has been unable to remedy because of the general tendency of college administrations to maintain the status quo.

The policy of the E. C. P. D. seems to be at present not to encourage further accrediting; at least it has discontinued the reëxamination and reaccrediting procedure which was to have been conducted beginning last year. It is probably doubtful if there will be many institutions accredited until the end of the war because of the loss of students to the Armed forces as well as the influx of various Armed forces training programs. In view of this, any comments relative to the basis for accrediting curricula should be restricted to a discussion of the post-war period.

I believe that it would be wise, in the post-war period, to maintain the sound basis for accrediting which has proved so effective thus far. By this I do not mean the establishing of a reactionary policy demanding no change, but rather a progressive plan looking far into the future. Actually, this is a restatement of the basic policy of the committee on engineering schools and I quote from Page 6 of the Tenth Annual Report, "—the avoidance of rigid standards as a basis for accrediting in order to prevent standardization and ossification of engineering education and to encourage well-planned experimentation." This policy is significant in view of the many changes which are indicated by present trends, and whatever the make-up of the committee on engineering schools, this sound policy should be adhered to.

In line with this it is expected and hoped that a number of major alterations will be made in our curricula as a result of the impact of the war and the revisions which we are now finding necessary in view of changing methods of production and design. I should like to point out a few obvious examples. The shortage of skilled help and the necessity for the rapid training of shop personnel has resulted in the development of what is known as "production illustration," where the various parts to be manufactured are not shown on blueprints using the conventional orthographic projection methods, but are illustrated by exploded views and perspective drawings which portray clearly and simply the information which the shop man needs. As another example, I believe that we must give more attention to the matter of "product design." There are few curricula, if any, where any attention is given to this item. Normally, I suppose it would come in the course which we might call "aircraft detail design." Some institutions now have this course as a technical elective.

Present indications point out a desirable increase in the length of training for special fields, such as advanced aerodynamics, advanced structures and the like, which would follow the basic courses of the four year curriculum. These basic courses, however should be closely related to the aircraft field. I do not believe that the education of an undergraduate aeronautical engineer should include laboratory courses on steam engines when courses in in-

ternal combustion engines and in aircraft engine operation could just as well be offered. I believe that it is just as easy to teach a course in airplane structures as it is to teach a course in bridge structures with the hope that the student will be able later to make the transition from the use of empirical to the use of rational formulas and the transition from the use of low carbon steel and working loads to the use of aluminum alloys and ultimate loads. I believe that it is just as easy to teach aircraft detail design as it is to teach machine design.

Many of these changes will be brought about as a result of the E. S. M. W. T. program. However, the policy of substituting short, intensive, terminal courses for fully rounded curricula is not consistent with the proper development of the engineer as an individual. This development is one of the major functions of the E. C. P. D. and future curricula should carefully guard against a retreat from this principle.

A fundamental problem, and one which has given me concern ever since the inception of the E. C. P. D. program, is the lack of representation of the aircraft industry, or aeronautical societies, or aeronautical institutions, on E. C. P. D. committees. I was amazed to find that there was not a single aeronautical engineer, as such, on the many committees of the E. C. P. D. It is hoped that we have concluded our arguments about whether or not aeronautical engineering is a profession itself—that it is as different from mechanical engineering, or electrical engineering or civil engineering as they are from each other, although it may embrace many features common to these other fields.

The growing importance of our profession is recognized by many states through their various Boards for Registration for professional engineers. I feel that adequate representation should be accorded to this field in proportion to this increasing importance and because of the powerful effect which it will have on the progress and development of civilization.

We have in this country no such thing as the American Society of Aeronautical Engineers. There is no aeronautical organization that deals with the human problem and the individual engineer, such as does the American Society of Civil Engineers, and the American Society of Mechanical Engineers in their respective groups. I feel that such a society is necessary and desirable and its lack is the fault of ourselves as well as of the aircraft industry. I am not convinced that any other society composed principally of electrical engineers, or civil engineers or mechanical engineers, is qualified to deal with the needs of the professional aeronautical engineer.

The wartime period may not be the proper time for discussing the creation of such an organization. However, we had better be thinking about it, and I expect that most of you have given such a proposal considerable thought in the past years. Whether this end can be obtained by the creation of a new technical society or whether it might be reached through the establishment of a branch or an affiliation with an existing organization, I am not prepared to say at the present time. Nevertheless, I believe that this is an important item as far as the aeronautical relationships with E. C. P. D. are concerned. When the aeronautical profession is as well recognized as other professional engineering groups then, and only then, will we achieve the desired degree of satisfactory relationship with the E. C. P. D.

Aeronautical Education in Light of Experience at Naval Aircraft Factory*

By LT. L. R. PARKINSON
Raleigh, N. C.

In the present day of infinite numbers of reports and the emergency of war, it is important that the first paragraph of each report contain a summary in order that the reader will not waste time briefing through many subjects in order to find out that the material is of no immediate interest. This is particularly important at the Naval Aircraft Factory where we receive reports covering every conceivable subject from fishing from a rubber life raft on the international date line to the theory of electronics. Following this procedure, I will state that I do not recommend any change in the present aeronautical engineering curricula by virtue of experience at the Naval Aircraft Factory.

Now that does not mean that some changes might not be beneficial. There are undoubtedly changes which would be most desirable, but no more to the Naval Aircraft Factory than to the industry in general. The Naval Aircraft Factory has many functions under the Bureau of Aeronautics. It is a research and experimental organization and even its production program is of a research nature. Congress decreed that the Naval Aircraft Factory must have a production program which could be used by government agencies as a yardstick for the measure for private industry. Every piece of aeronautical equipment used by the Navy must undergo tests and be accepted by the Naval Aircraft Factory before it is placed in service.

The personnel may be divided into two distinct classes, naval and civilian. The bulk of the engineering work is done by civil service employees, the naval personnel acting largely in a supervisory capacity. As far as aeronautical engineering education and the naval personnel are concerned, the colleges are not in a position to train men for every duty which might be assigned by the Bureau of Personnel. Certainly not even the often mentioned five-year curriculum could encompass all the possibilities. Except for a more thorough exposure to the basic engineering subjects I can see no need for change in the current aeronautical engineering curricula as approved by the E. C. P. D. It appears, consequently, that we must omit the service personnel from consideration. Inasmuch as the percentage of naval officers in the engineering department is small, no appreciable error will be made.

Much has been said about liberalism in aeronautical engineering and apart from the so-called cultural reasons

* Presented at the 50th Anniversary Meeting, S. P. E. E. (Aeronautical), Chicago, Ill., June 18–20, 1943.

advanced by the liberal arts departments, the main reason is that there is no way of telling in which phase of aeronautical engineering the graduate will eventually take his place. We all have had students tell us that the curricula should contain more fluid mechanics and simply because that particular student is very actively involved in the design of hydraulic systems. His classmate will probably say that he never uses the fluid mechanics, and he thinks that in its place should be more on ballistics. If all such comments from all the graduate aeronautical engineers were added up to a total number, it still would not equal the possibilities of comments from engineers at the Naval Aircraft Factory. Certainly we have every phase of aeronautical engineering known to the industry and perhaps a few more.

With so many opportunities how can any college be expected to produce aeronautical engineering graduates capable of filling any one of the many positions, especially when the factory always reserves the right to place the man where he is needed most at any particular time. Obviously, it is impossible. As a matter of fact, any aeronautical graduate coming into the engineering department of any of our large aircraft manufacturers must continue in the roll of student for many months. The same applies to those entering the service of the Naval Aircraft Factory. Should the engineer be assigned to the ordnance section, an interest in the work and a period of indoctrination will enable him to carry out the assigned project, providing he has had a thorough background in the rudiments of engineering.

At the present time the qualification most needed is experience. The Naval Aircraft Factory is no exception to other organizations in this respect. This is a fact well known to all educators, but unfortunately it is a qualification which is in greater need than ever before. Because of inexperienced help in the shops, more engineering knowledge is required. This takes time from design projects which also need the services of the experienced engineer.

If I were recommending any change in the aeronautical curricula it would be in the line of experience. It would seem possible that a little more practical work might be introduced into the curriculum even at the expense of the theoretical. I would estimate that not over three per cent of the aeronautical engineers are engaged in aerodynamics or stress analysis and, in any case, for that type of work the normal curriculum should be supplemented with graduate study. The bulk of the engineers are faced with practical problems. For example, a contractor sends in some stringers which have the holes drilled in the wrong places and are too short. The factory can neither afford to hold up the production line until new ones are made nor to scrap the material. It is realized that a lot of small companies are now making airplane parts that formerly might have been producing steam rollers. To produce the necessary number of airplanes we must use whatever sources are available. The problem is what are we going to do about the stringers. The experienced engineer would probably decide that the wrongly located holes could be filled up by flush riveting and the shortness might be corrected by splicing pieces on the end, picking up the holes that normally would be drilled in the skin. There would be nothing to mar the outward appearance and

experience would tell the engineer that this method would be structurally satisfactory. This is a relatively simple problem, but it is one which baffles the average graduate because in his airplane design classes he never dealt with anything but perfect material. An eraser corrected all errors.

The materials of construction are of vital importance. Wood and plastics certainly deserve consideration in the curricula. We have learned new methods of fabrication and construction so that a knowledge of metals is not enough. There are many materials which in the early days of the war were considered as substitutes. It may well happen that after the war, it will be the metals which will be the substitutes. Such a possibility is one that the educators should keep in mind when planning post-war curricula. It has been estimated that 95 per cent of our war-time developments are but new applications of prewar knowledge, but so many of these concern the field of aeronautics that we may find it necessary to revamp the course of study. Many graduates are amazed to find that what they had been told in class was impossible is being successfully accomplished at the Naval Aircraft Factory. However, adjustment to post-war practices will be a normal evolution and I will stand by the original statement that at this time I do not recommend any change in aeronautical education.

Patents and Progress*

By ARTHUR SIMON

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During the last few years we have witnessed a great deal of discussion about patents and our patent system. It therefore behooves us as citizens to study the subject. This applies particularly to the engineering profession, which together with industry will be exposed to the full impact of any changes in the patent law. I believe that the feeling of your program committee of the necessity for such a study by engineers is the reason why I was asked to present this paper.

Patents form an important link in our economic system and it is therefore in order to discuss the basic principles of the patent system, what it has accomplished, and then to discuss in a general way the alleged defects and some of the proposed remedies.

Reason for Patents

The Patent Law was created by Congress under a constitutional provision,

> "to promote the progress of science and the useful arts by securing for limited times to inventors the exclusive right of their discoveries."

It is in the language of Chief Justice Marshall:

> "the reward stipulated for the advantages derived by the public for the exertions of the individual, and is intended as a stimulus to those exertions. The public yields nothing which it has not agreed to yield; it receives all which it has contracted to receive. The full benefit of the discovery, after its enjoyment by the discoverer for 17 years is preserved; and for his exclusive enjoyment of it during that time the public faith is pledged."

Origin of Our Patent Laws and Patent System

The tools which primitive man used were his property. If he made an axe it was his property only as long as he retained actual possession of it. If he left it lying about accessible to others and someone else took it, he could do two things. He either regained possession of the axe by force or he made another axe for himself. In other words, in primitive society physical control of a thing was the only way of owning property, and the stronger man could take from the weaker. It was early recognized that this was wrong and public conscience organized an effective sentiment against such forceful taking possession and evoked the theory of "title." If a man has a title to a thing he came to it lawfully and cannot be deprived of it except by his own voluntary act or by operation of the law. Even primitive man, then,

* Presented at the 50th anniversary meeting, S.P.E.E., Chicago, June 18–20, 1943.

recognized the necessity for preserving ownership by prescribing punishment for the robber or the thief.

The maker of the first axes, however, could not keep anyone else from making a copy thereof for himself. In the early stages of man's industry there was no need for preventing such copying of ideas, but as industry developed and division of labor took place so that a certain individual went into the business of making axes exclusively and depended upon it for his living, he naturally wanted to keep for himself any improvement in axes which he invented, but there was no law by which anyone who bought an improved axe from the inventor could not make a copy thereof and be a competitor of the first inventor. Of course, the first inventor could keep the idea a secret. In other words, he could keep the ownership of the idea, but that would not help him in gaining his livelihood, nor would it help the users of axes. Thus it became recognized that a man should have a property right in his *invention* just as much as he has in the *thing itself*. The idea of the property right in inventions developed rapidly at the stage in our economic development which brought about the division of labor and the factory system known as the Industrial Revolution.

The Industrial Revolution coincides with the American Revolution. The latter emphasized the rights of the individual; and the Constitution and the statutes based thereon gave the inventor not merely property rights, but also the right to own his ideas. The right of an individual to own his ideas is a natural right, but the government under the Constitution offers to the inventor a contract to protect him in the enjoyment of the benefits of his idea in exchange for an immediate disclosure thereof to the Public. The Government does not give the right to manufacture or sell. Everyone had that right before the Constitution. What the government does through a patent is to give the right to *exclude others* from making, selling, or using an invention without the inventor's permission.

To obtain a patent a man must make public disclosure of the subject matter of his invention. After 17 years, during which his right to exclude others from the use of his invention continues, it becomes public property. Furthermore, during these 17 years anyone may improve on the invention. This is often done so thoroughly, that long before the expiration of the patent it becomes commercially worthless without the improvement.

What Does a Patent Protect

The development of an invention into a marketable product is in most cases a slow and expensive process and the final success is by no means assured by prodigious expenditure of time, effort and money. Without patent protection the inventor or his financial backer would have no assurance that the commercial exploitation of the invention would return to him a reasonable compensation for his efforts, privations and the risk which he takes. He would not even be assured of the return of the money spent in developing the invention; much less of a profit. It is obvious that as soon as an inventor puts on the market an improved product without having any protection, competitors can copy that product and not having to recoup the cost of the pioneer work they can perfect the final design and can undersell the inventor and thus put him out of busi-

ness before the inventor ever has realized anything out of his invention.

What Have Patents Accomplished?

The patent system of this country, which has been adjudged by many observers as the most stimulating of all the patent systems in existence, has contributed more than any other single factor to the development of this country as the greatest industrial nation. A partial list of pioneer inventions from the beginning of this country to the present date will confirm this statement and the previous statement as to the necessity of protecting the struggling inventor and his financial backer against the acquisitive instinct of others who would attempt to take from the inventor the fruit of his labor by copying his invention.

The history of a few basic inventions with which you are familiar illustrates the point. In many cases a great deal of work and patience was required to introduce the invention to the public. In other cases large amounts of labor and money had to be spent before the invention was perfected. In still other cases the inventor after having obtained a patent had to defend it at great expense in time and money before he reaped any real benefits. Among these basic inventions are the following:

Cotton Gin	Whitney
Telegraph	Morse
Reaper	McCormick
Rubber	Goodyear
Sewing Machine	Howe
Water Turbine	Francis
Machine Gun	Gatling
Typewriter	Sholes
Air Brake	Westinghouse
Telephone	Bell
Lamp	Edison
Linotype	Mergenthaler
Motion Picture Machine	Edison
Airplane	Wright Bros.
Ductile Tungsten	Coolidge
Anti-knock gasoline	Midgely
Television	Zworykin

These basic inventions have made large contributions to this country's greatness. In addition there are the many thousands of improvement patents, the cumulative effect of which has been equally great. They have given us the many consumer's goods and services which have raised our material standard of living way above that of any other nation. The inventions of the tools which make possible the production of these consumer's goods in vast quantities at ever decreasing costs despite improved quality is a tribute to the stimulating effect of the patent system upon all of our economic and it may be added scientific activities.

These primary inventions were in themselves rarely of practical usefulness. Very often as with the telephone, airplane and vulcanized rubber, the principle on which they operated was not well understood and research scientists immediately set to work to investigate their theory of operation. This research led to new facts and theories which in turn supplied the inspiration for thousands of improvement inventions, which increased the usefulness of the basic invention and extended its general use. Without these improvement patents the original invention would ultimately have been abandoned and forgotten. Thus both basic and improvement inventions stimulate research and research in turn stimulates further invention. This mutual stimulus is very frequently not confined to the field of the original invention, but reaches into other fields which before may have had only little or no direct relation to the original field.

Among the many products into which

the inventions of thousands of inventors have been built, are the radio, automobile, moving pictures and the refrigerator. You can think of many others. These things could not have been produced and we could not have established in such a short time the splendid and almost unbelievable production records of the present struggle, if there had not been a collateral improvement in production tools. Among these improvements are the welding of metals, the almost human automatic production machines, such as presses, multiple spindle lathes, automatic millers, shapers and grinders, and many more. Prof. Millikan recently pointed out that Technology and Science mutually benefit each other. New scientific discoveries lead to new inventions and inventions in turn provide improved tools for scientific research.

Mr. Kettering stated recently that the cost of a precision built automobile at the beginning of the war was about twenty-five cents per pound, which should be compared with cost of production of our dairy products and their price to the consumer. Many of the items though produced by highly complicated processes, are obtainable at astonishingly low costs. Thus an electric clock, an electric iron or a toaster can be bought for a couple of dollars. The cost of electricity is so low and the generation and distribution has been advanced to the point, where power is available to almost every home in the country.

How Does the United States Patent System Compare with the Patent Systems of Other Countries?

In the United States the patent is granted to the first inventor and to the inventor only. A government fee is payable in two installments, the first upon application and the second upon allowance of the patent, and these are the only government fees collected during the life of the patent.

The Patent Office makes an examination for novelty; and any prior publication in this or in any other country, or any prior disclosure of or use in the United States except for one year prior use by the inventor, prohibits the issuance of a patent.

Great Britain

There is only a limited examination for novelty. A preliminary specification may be filed prior to the completion of the invention. The application is published prior to issuance and other parties may oppose the grant of a patent. The term of the patent runs from the date of the application. An annual tax is levied to maintain the patent in force. The patent is granted to the one who files first, who is not necessarily the inventor.

Germany

The examination for novelty is similar to that in the United States. The application is published prior to the grant of the patent to permit others to oppose the issuance of the patent. The patent runs from the date of the application. An annual tax is levied to maintain the patent in force. Patent infringement is a criminal, as well as a civil offense. The patent is granted to the one who files first, who is not necessarily the actual inventor.

France

There is no examination for novelty, but merely a registration or declaration by the applicant. The claim does not specifically define the invention. The patent runs from the date of ap-

plication. An annual tax is levied to maintain the patent in force. Infringement of patents is a criminal as well as a civil offense.

It will be noted that of all of the countries mentioned only the United States does not levy an annual tax to keep the patent in force. Germany and England publish the application prior to the issuance of the patent. Only in the United States does the term of the patent run from the date of issue, while elsewhere it runs from the date of application.

The average number of patents annually granted in the different countries is as follows:

United States	48,000
Germany	20,000
France	19,000
England	19,000
Italy	11,000
Canada	9,000
Switzerland	7,000
Belgium	7,000

From this it will be seen that United States grants more patents than Germany and England, or Germany and France combined, which is a testimonial of the ingenuity of our American people. When we figure the number of patents on a per capita basis we are still ahead of any other industrial country.

We often hear it said that the American patent system gives an unfair advantage to foreign patentees. This also is disproved by figures. The percentage of patents granted to foreigners in the respective countries is as follows:

United States	13%
Japan	24%
Germany	26%
France	50%
England	52%
Switzerland	56%
Italy	64%
Canada	90%

As the U. S. market is the largest individual market for industrial products in the world, it is quite natural that foreigners seek patent protection for their inventions in the U. S., and yet the percentage of patents granted to foreigners in the U. S. is only 13 per cent, or less than half the percentage granted to foreigners by any other industrial country.

It is also interesting to contemplate that:

42½ per cent of the U. S. Patents granted annually are to individuals,
35 per cent to small corporations,
17½ to large corporations,
4 per cent to foreign corporations.

Thus the total number of patents granted in the United States to foreign corporations is insignificant compared to the total. Also the number of patents granted to individuals and small corporations combined is more than three-fourths of all the patents granted in this country, which hardly bears out the charge of monopoly of large corporations through patents.

Alleged Defects of the Patent System and Their Remedy

Periodic agitation for reform of the patent system is as old as the patent system itself. No part of our legal structure is without defects and the agitation to reform the patent system is not unique. On the contrary, the patent system shares this agitation with all other branches of our statutory laws.

Most of the proposals for reform oversimplify the reform problem. In fact those who talk loudest and ask for the most revolutionary reforms appear to know the least about the subject in general and the practical working of the system in particular. They

often set up a phantom and then plead for a war of extermination against the phantom with all the emotional appeals which they can corral. That is obviously not the way to remedy any evil. A remedy to be successful must be based on a sound knowledge of the situation and a careful analysis of the possible effect of the proposed remedy.

The President of the United States aware of the complexity of the problem has appointed the Patent Planning Commission which is comprised of eminent and competent members who are studying the problem at the present time in all of its phases. It is my belief that no legislation for permanent changes of the patent laws should be passed until the report of that Committee is received. The reformers, however, are impatient and for political reasons are pressing for immediate action on some very radical proposals, which in the opinion of competent unbiased judges should not be passed.

While at first blush it appears that some basic changes in our patent laws might be desirable, an unbiased study will show that most of the faults of our patent system are in the administration of the system rather than in the basic law. Let us examine some of the attacks on our patent system. There is the proposal to require payment of an annual tax, such as is levied in other countries to keep a patent alive, in order to weed out the so-called "paper patents." A paper patent is supposed to be a patent which has not come into public use. Those who are for radical reform call any patent that has not come into public use a paper patent. But among these patents, are many which are ahead of their time, and which are the seed out of which a new art grows. They are not useless and restrictive patents. They cover inventions which cannot be commercially put into practical use because either the public is not yet prepared to use them advantageously, or because that branch of technology to which they belong has not generally advanced sufficiently far towards practical applications.

As soon as they are published these pioneer patents become the text and are the inspiration of other inventors who perfect on the original idea until ultimately technology catches up with the inventor of the basic idea, and it together with its improvements result in an article offered to and used by the public.

I only wish to cite one example of a primary patent which has been instrumental to release inventive thought in many directions. We are at the threshold of a revolutionary change in the supply, control and conversion of electric energy from one form into another, by means of electronic tubes which have been perfected in the last decade. The basic idea of these new systems is contained in early patents, some of which expired many years ago. Thus the control of electric motors by means of electronic tubes was invented before the last war and since that time many hundreds of patents have been filed to perfect the original invention, so that today all that is required is the perfection of tubes for specific applications to bring about a complete revolution in the transmission and application of electric energy.

Without a patent system and especially without the requirement of a complete disclosure in the early basic patents the latter work would most certainly not yet have been done. The development of the large tubes required for the application mentioned was initiated by the need for such tubes

indicated by these early patents. It is apparent that the basic idea generated others and extended the field of invention and research in ever widening circles. It is thus not extravagant to state that many primary patents which expire before being put to industrial use greatly advance our industrial development. I can therefore see no reason for eliminating such patents, which as I have indicated, strengthen rather than hinder our industrial progress and at the same time give the inventor some small recognition and reward for his efforts.

Another reform which has been suggested is compulsory licensing. It is proposed that an inventor should be compelled to grant licenses to any responsible party who asks for it, and furthermore that these licenses should not be restricted as to the field of use and the territory of exploitation, and that no price or quantity restrictions should apply. That would mean, however, as I have indicated before, that an inventor or his financial backer, having spent a great deal of effort, time and money to put an invention into commercial form, would have to grant a license to competitors among whom might be a large corporation with unrestricted resources. This competitor, not having had to invest the venture money necessary to bring the invention into marketable form, could undersell the original inventor and could sell the product at a loss for a time to put the original inventor or manufacturer out of business, the licensor having signed his death warrant when he signed the licensing agreement.

Such laws and similar laws would most effectively reduce the number of patents taken out and in force, but at the same time they would dry up the source of any progress, because the inventor would have every reason to withhold patent application and to keep his knowledge to himself. Under present conditions he cannot afford to go into a venture without a patent. Under compulsory licensing to competitors he could not afford to go into a new venture with a patent.

The inventors of many of the primary inventions which I have mentioned would have had no incentive to doggedly pursue their work had there not been a ray of hope of ultimately obtaining a reward for their persistence, privations and disappointments.

In this paper it is only possible to dwell briefly on some of the phases of the patent system and of the proposed reforms. Stimulated by the depression and the more recent war hysteria a large group of would be reformers have proposed all sorts of panaceas, which include the complete emasculation and even abandonment of the patent system. Most of these reformers are ill-advised and are little informed as to the real nature and working of the system.

Many of the would be reformers apparently take the position that the ends to obtain their objective justify the means. Thus Senator Kilgore, the author of the Science Mobilization Bill, in a letter to the Senate Military Committee quoted the National Academy of Science as having endorsed that bill, when as a matter of fact the Academy had not even considered the bill. I call your attention to a statement by the Academy published in the A. A. A. S. Bulletin of May 1943, in protest against the worthy senator's deception. The Kilgore bill and other bills entirely ignore the impact of the proposed regimentation of scientific and industrial research on the profes-

sional and material welfare of the lives which are devoted to such research.

I have purposely not discussed any of the specific bills which have been proposed to Congress in connection with these reforms. I trust, however, that my paper will have the effect of prompting you to study more in detail the problem which is most important to all of us. I recommend to you who are responsible for the training of the coming generation of engineers, that engineering students be given more comprehensive instruction in the basic principles of our patent system which is such an important link in our economy and which has had such a great stimulating effect upon the creative ability of the American engineer.

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A College Course in Construction Engineering*

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The present war has dislocated practically every form of normal human endeavor. The tremendous task, after victory, of converting to peace-time pursuits may either go in the direction of seeking to return to the "status quo" of pre-war days, or it may be utilized as the opportunity for establishing advancement in those endeavors. At the present time, practically all scientific and engineering colleges have experienced a dislocation in their teaching methods and in their subject matter, to provide training which will be most effective in the war effort. In preparation for the eventual re-conversion, this appears to be the time to stimulate some "post-war planning" in educational institutions to the same extent as is being promoted currently in industrial and public works programs.

Most "post-war planners" are convinced that conversion to peace-time pursuits will call for a tremendous construction program, both private and public works, extending over many years. In fact, it is generally regarded as a fundamental necessity to the preservation of our American system of enterprise. Construction skill and ingenuity will be taxed to the utmost in producing the most for each dollar expended. Under such a program, trained construction engineers in all grades will be needed on a large scale. Professor M. I. Evinger has pointed out that World War I brought forth the need for a new course called Industrial Engineering which is now offered in many colleges; World War II will probably shape the general development of a course in Construction Engineering. In 1939, C. C. Williams, President of Lehigh University, suggested that "Just as industrial engineering as a variant of mechanical engineering has attained a merited recognition, so a variant of civil engineering pertaining to construction and contract procedures might well be instituted in the larger colleges."

The need for better courses in construction engineering has been under discussion for many years. In 1941, a sub-committee was set up in the S. P. E. E. under the chairmanship of Professor Malcolm S. Douglas to recommend a suitable course. After considerable study, it appears that it is not feasible to design a so-called standard course in construction engineering. There are too many variable factors among the colleges, such as half year and quarter year semesters, organization of faculty and personnel, and variety of physical facilities. In view of this, the following paper has been prepared as a recommendation for general guidance.

* Prepared for the 50th Anniversary Meeting, S. P. E. E. (Civil Engineering), Chicago, Ill., June 18–20, 1943.

Before putting this paper into final form, a preliminary draft has had the benefit of a review by many noted educators and civil engineers and their important suggestions are gratefully acknowledged.

Reports by S. P. E. E.

Since about 1935, the Society for the Promotion of Engineering Education has had a sub-committee in its Civil Engineering Division devoted to the subject of construction education. The Committee has developed several unpublished reports and preliminary surveys. The most notable one was issued in June 1941, under the chairmanship of Professor M. I. Evinger of the University of Nebraska on the subject "Content of Courses Pertaining to Construction." This report presented a general survey of construction courses offered up to 1940 by colleges in the United States and Canada.

The following is a significant quotation from this report:

> The information furnished by this survey indicates that a real need exists for a stimulated and continued study of the numerous questions pertaining to the general policies and problems arising from the increasing introduction and development of courses in construction.

The latest available catalogue descriptions were used as a basis for compiling information on courses having some direct relationship to the general field of construction. About 45 colleges are offering courses such as cost estimating, quantity surveys, construction methods, building construction, earth work and grading for highways and railroads, and similar subjects.

The general impression from this report is that most colleges are offering what might be called a smattering of construction engineering. At the present time, apparently only one institution, Massachusetts Institute of Technology, gives full weight to a curriculum in construction engineering leading to the degree of "Bachelor of Science in Building Engineering and Construction."

According to a survey made by the U. S. Bureau of Labor Statistics, about 44 per cent of all civil engineering graduates are engaged in some phase of construction. The remainder are employed in other fields, such as design, research, operation, consulting, teaching, sales, or general administration. A further significant point is found in the distribution of members in the various technical divisions of the American Society of Civil Engineers. Of the twelve technical divisions, the Construction Division has the largest enrollment with 20.0 per cent of the total membership. The Structural Division ranks second with 16.8 per cent. The other ten divisions range in membership from 11.5 per cent down to 3.1 per cent. On the basis of these statistics, the sub-committee of the S. P. E. E. implied that educational institutions are not designing their civil engineering courses in the direction in which most graduate engineers eventually find themselves engaged.

The report quotes a very good editorial which appeared in *Engineering News-Record*, December 20, 1928, on the great need for technically trained personnel in the construction industry and on the benefits from such a policy.

The report also contains a table which gives the following data with respect to the introduction of courses pertaining to construction in the colleges:

COURSES BEING OFFERED BY ENGINEERING COLLEGES IN UNITED STATES AND CANADA PERTAINING TO CONSTRUCTION

Year	Total No. of Courses
1922	5
1925	18
1930	48
1935	58
1940	72

The report further states that in 1941, seventy-seven (77) courses were being offered under fifty-seven (57) different titles. Some titles do not clearly indicate the scope of the subject matter. This apparently reflects the complexity of teacher viewpoints on the character of subject matter considered especially suitable for any classified branch of construction education. Teacher viewpoints are still considered in a state of flux. Quoting further: "Patient effort over a period of time will be required to effect a reasonable reduction in the diversity of construction courses and to evolve improvement in the classification of their essential subject matter. There is an urgent need of developing rational minimum specifications on the aims and content on construction courses, particularly, of those that bear the same or very similar titles."

From the comprehensive table of courses presented in the report, the writer found that they may be generally classified under the following headings:

Subject	Number of Courses Offered
Estimating and Cost	33
Construction Methods	15
Construction Management and Economics	14
Building Construction	14
Safety	1
Labor Relations	0
Total	77

These courses are being offered by 45 different schools.

The S. P. E. E. report further states "Apparently teachers of courses pertaining to construction are having difficulty in adapting available text books to the requirement and objectives of such courses. There is a dearth of suitable text books for many of the courses as now set up. The lack of suitable text books has resulted in a development of departmental notes for use in connection with a dozen courses."

"At present, instructors must rely largely on current technical magazine engineering reports, and other miscellaneous publications. Engineering literature on the *methods and costs* construction is very extensive; that the *whys* or the basic economic *reaso* for adapting a specific plant and organization to a given constructional project, is relatively deficient in quantity and quality. Since the thrivi activities of the construction industry produce the energizing materials and stimulating problems that are essential to the improvement and advancemer of construction education, and sin the publishers of technical literatu have superior facilities for gatherir and disseminating materials of pert nent educational value, publishe should be encouraged to give greate emphasis in engineering literature t the fundamental economic and tech nical aspects of building and enginee ing construction."

Most colleges employ auxiliary aids such as lantern slides, manufacturer catalogues, plans and specification non-faculty speakers and inspectio trips.

This could be further develope through closer coöperation of teacher in construction engineering with th

local chapters of the Associated General Contractors of America, by inviting such teachers to attend chapter meetings devoted specifically to this or related subjects. In a few instances, contractors have participated in setting up and taking part in lecture courses.

It is hoped that some of the leaders in the construction industry can be persuaded to offer scholarships for superior students, endow chairs in labor relations and other construction subjects, or sponsor the writing of urgently needed textbooks in which their important experiences are recorded.

For convenient reference, the following is a partial list of publications which are available at the Washington office of the Associated General Contractors of America; most of these are useful for educational purposes.

Contractors' Equipment Ownership Expense
Equipment Rental Agreement
Equipment Record—Bond Paper
Equipment Record—Cardboard
Highway Estimate Sheets
Building Estimate Summary
Job Overhead Summary
A. G. C. Proposal Form
Standard Contract for Engineering Construction
A. G. C. Cost Plus a Fee Contract
Construction Service Contract—Principles and Practice
Standard Government Contract and Instructions to Bidders
Standard Building Contract of the American Institute of Architects, Rev. 5th Edition
Subcontract form—Amer. Institute of Architects, Rev. 5th
Classification of Construction Occupations
Construction Investment Bonds
Functions of a General Contractor
Advantages of Winter Construction
Facts, Contract or Day Labor Methods
Accident Prevention Manual

Need for Engineers Trained in Construction

The S. P. E. E. report states: "There seems to be a general agreement that the character of the construction industry is being transformed and that the quality that it is demanding of its future leaders are broadening vastly."

It is essential that civil engineering colleges give at least the same recognition to the various functions of construction, as is now given to design, operating and other functions. To meet the demands of the construction industry for civil engineers trained in construction engineering, it appears that the most practicable approach would be for a limited number of relatively large engineering colleges located in different parts of the country to provide an option in construction engineering during the junior and senior years. This would include such courses as construction methods, estimating and costs, management and economics, labor relations, safety, contract law and similar items, as described in the following:

Suggested Course in Construction Engineering

The accompanying Table "A" gives a suggested course in construction engineering. This is based on some of the existing courses in Civil Engineering and retains most of the fundamentals and such basic subjects as "materials," "structures," and "design." These should be retained because, as one contractor's engineer re-

cently remarked: "With new graduates, it is much easier for us to broaden the specialized training than to patch up the basic." During the third year and, more particularly, in the fourth year, various courses are suggested which deal primarily with the field of construction. Completion of the course would lead to the degree of "Bachelor of Science in Civil Engineering (Construction)." This training is not intended to develop engineers only for the contracting industry, but also for designing organizations and consulting engineering firms. For this reason the scope of the course is rather broad and

TABLE A

SUGGESTED COURSE MAJORING IN CONSTRUCTION ENGINEERING FOR CIVIL ENGINEERING COLLEGES

Year	First Term		Second Term	
	Title	Hours Per Week	Title	Hours Per Week
1st	Algebra and Trigonometry	5	Calculus	5
	Chemistry, General	4	Descriptive Geometry	5
	Physics	3	Chemistry, General	4
	Engineering Drawing	6	Physics	4
	English Composition	3	English Composition	3
	Military Science	3	Military Science	3
	Physical Training	1	Physical Training	1
	Total	25	Total	25
	Summer Employment (coöperative on construction work)			
2nd	Calculus	5	Differential Equations	5
	Applied Mechanics	4	Applied Mechanics	4
	Applied Physics	3	Railways and Highways	3
	Materials—Steel and other Metals	3	Engineering Economics	3
	Report Writing	2	Engineering Geology	4
	Surveying and Topographic Dwg.	5	Writing and Public Speaking	3
	Economics	3	Hydrology	3
		25		25
	Summer Surveying at Camp (surveying, railways and highway, field work—hydrographic survey)			
3rd	Applied Mechanics	5	Structures—Theory—General	3
	Materials Testing Laboratory	3	Thermodynamics	4
	Materials—Wood and Masonry	3	Hydraulics	3
	Elements of Elec. Engineering	4	Accounting, Purchasing, Warehousing	4
	Electric Engineering Laboratory	2	Construction Methods and Equip.	5
	Building Construction	5	Elec. Motors and Controls	3
	Construction Inspection	3	Diesel, Gas and Steam Engines	3
		25		25

TABLE A—*Continued*

Year	First Term		Second Term	
	Title	Hours Per Week	Title	Hours Per Week
	Summer Employment (coöperative on construction work)			
4th	Structures—Theory Timber and Reinf. Concrete	5	Structures—Theory Steel	4
	Structural Design—Timber and Concrete	5	Structural Design—Steel	5
	Water Supply and Sewage	3	Foundations and Soil Mech.	4
	Heat Engineering, Ventilating and Air Conditioning	4	Labor Relations, Health and Safety	4
	Eng. Law Contracts and Specs.	3	Contracting	3
	Construction Estimating and Costs	5	Job Management	5
		25		25
5th (Optional)	"Internship" of Experience on a Construction Job for one (1) year, including preparations of a detailed thesis describing job experiences and methods to demonstrate the student's capacity for observation. This thesis is to be applied toward a Master's Degree.			
5th or 6th (Post-graduate) (Optional)	Contract Law II	4	Ethics	3
	American Government and Politics	3	Finances—Balance Sheets	3
	Labor Relations II	3	Public Works—Policies and Management	5
	Applied Soil Mechanics	4	Personnel Training	4
	Option	3	Option	4
	Option	4	Option	3
	Option	4	Option	3
		25		25
	List of Options:			
	Machine Design	4	Motion and Time Study	3
	Plant Design	4	Advertising and Sales	3
	Production Control	3	Foreign Trade	3
	Report Writing and Public Speaking	3	Electrification	4
	Advanced Management	3	Languages	
			History	
			Liberal Arts Subjects	

includes considerable design and such subjects as "Inspection" in which field many young engineers find themselves during their first years out of school, often with inadequate preparation or with a misguided mental attitude.

In adopting this course, certain modifications in semester hours, sequence and scope would, no doubt, be required to suit the policies of the individual colleges. In some schools, it may prove advisable to organize the construction engineering courses so that they would fit into a suitable post-graduate course for those who have already completed their civil engineering training and who wish to return for another year in this field of work.

In general the course should be designed to build up a mental attitude of "how can the job be best accomplished," considering factors of time, cost, and personnel available. The necessity of keeping up-to-date by reading current literature should also be stressed. However, as one noted engineering educator has pointed out, "we should remember that the primary function of our colleges is not to disseminate information but to train young people's minds. Information as such may become obsolete, but any development in the power of analysis is never lost. Construction can be used effectively to develop the power of analysis; any tendency to make construction courses into information courses should be avoided."

It is further suggested that the various courses on construction subjects be standardized under the following general designations:

1. *Building Construction*

Matters relating to the engineering design and construction of buildings including problems of the architect, the engineer, the builder and the materials manufacturer in the process of planning and erecting structures. Building codes, inspection, interpretations of building plans, quantity surveys. Construction methods in erecting buildings, sources of materials and precise scheduling, delivery and use of materials. General contractors and subcontractor on building construction, specialist subcontractors, trade unions and jurisdiction in the various trades. Quality construction, mass production of smaller buildings.

2. *Construction Inspection*

Function and responsibility of an Inspector, obligations towards supervising engineer, contractor and client, judgment vs. prejudice, interpretation of specifications. Criteria for inspection, testing, inspection reports, method of inspecting raw materials, steel fabrication, cement, aggregates, concrete, building work, earth and rock work, construction methods.

3. *Construction Methods and Equipment*

Study of various types of construction equipment such as excavating, hauling, crushing, aggregate, concrete mixing and placing equipment, cranes, conveyors, tramways, dredges and the application of such equipment to various construction projects. Combinations of equipment for most economical plant layout. Planning of a construction plant as applied to a building, highway,

or lock and dam project (as selected), comparison of competitive construction methods for economic study. Equipment costs, rentals, maintenance, depreciation and obsolescence.

4. *Construction Estimating and Costs*

Methods for arriving at the labor and material costs of various construction operations and project features (preferably working from a given set of plans and specifications), demonstrating the difference between preliminary engineering estimates and contractor's bid estimate of cost. Equipment operating cycles, time studies, man-hour analyses and comparison, overhead and supervisory costs, analyzing prospective work, preparing bids, unbalanced bids.

5. *Job Management*

Preparatory work, camps, shops, temporary roads, power, water and air supply, job organization, functions of various departments, superintendent's duties, progress schedules, equipment, labor and financing schedules, production and cost graphs, job cost engineering, management analyses of costs and equipment performance for economic improvements, time keeping, materials ordering, expediting, receiving.

6. *Contracting*

Functions of contractors, risk taking, rights and obligations of contractors, general organization of construction companies and field organizations, personnel management, bonding, money and banking, relationships with supervising architect, engineer, and client: lump sum, unit price, cost-plus fixed-fee, cost-plus-percentage, bonus and penalty forms of contracts, force account and day labor methods, analysis of contracts, interpretation of specifications, ethics, memberships in trade and professional associations.

7. *Labor Relations*

Structure of American unions, typical labor contracts, agreements on wage scales, jurisdictional disputes, arbitration, mediation, labor laws, federal, state, and local agencies dealing with labor matters, relations with stewards, business agents and labor leaders, slow-downs and strikes, apprenticeship systems, methods of employment and discharge, exit interviews, morale building techniques, bonus and incentive systems.

8. *Health and Safety*

Numerous safety measures on construction jobs such as ladders, scaffolding, protective canopies, limit switches, protective devices on equipment, gear guards, life-saver vests for working near water, respirators, precautions in compressed air work, first aid, medical examinations, dispensaries and local hospitals, educational programs in health and safety, workmen's compensation, accident statistics, frequency and severity rating, benefits from safety programs, obligations of employer, insurance protection for employer and employees.

Method of Teaching Job Estimating

For several years, Columbia University has employed a method which has proved highly satisfactory in the teaching of estimating and bidding. A set of plans and specifications is secured of some current work in the New York area involving about $100,000 in cost. The students in the course are divided into four or more groups of engineering contracting companies, and they go through all the processes of job analysis, study of plans and specifications, and preparation of bids which are submitted near the end of the term. This provides point and purpose to the course, and through competition stimulates an excellent spirit in the work. The student response is reported as having been excellent under this plan. This might be supplemented by having some of the superintendents or engineers who are directly connected with the job under study come in for lectures to describe the methods actually adopted and the reasons for them.

Miscellaneous Features of a Course in Construction Engineering

The accompanying table of a suggested course contains reference to summer employment under a coöperative system. It is obvious that students as well as instructors, must get as much practical experience as possible right out on construction jobs in order to develop a better perspective and understanding about the subjects which are being offered. The colleges must take the initiative in working out coöperative employment arrangements with contractors, and, no doubt, the progressive contractors will demonstrate themselves to be very coöperative.

It is frequently claimed that students cannot get employment because of closed shops and union rules. However, this not a fair complaint. Many labor leaders recognize the advantages of having supervisors who are well trained in construction, and apprenticeship training on the supervisory side is just as important as on the labor side. Several contractors have demonstrated that there is no difficulty in writing in to their labor agreement a clause which permits the employment of five (5) engineering students for every one hundred (100) union employees on the job. Such students are paid the same rate as union employees if they are engaged directly on the work as helpers.

Students should be encouraged to recognize the advantages of working with their hands during summer employment, and in getting first hand contact with construction tools and construction methods. Membership in the labor unions is not required, but some unions have offered summer membership cards to students at nominal rates. Students should not be discouraged in accepting membership under such an arrangement. Union membership is quite a different matter when they are graduate engineers in the process of developing themselves for their profession, but in the pre-professional experiences, they can do well to study union organizations and union methods from the inside, in order to be better qualified to deal with collective bargaining problems when they are in executive positions. An intelligent understanding is bound to lead to better labor relations and benefits for both the employer and employee.

In discussing this matter with one of the most progressive and successful contractors in the country, he said: "Any course on labor relations should stress the importance of fairness in the handling of labor matters. The one big drawback in labor relations is in many cases a feeling of distrust on the part of both the employer and the labor representative. If we once eliminate this element of distrust, we will have cancelled 75 per cent of our troubles. In this connection it might easily be that now and then a student would become sufficiently interested in this matter of labor relations to cause him to adopt it for his life work. This of course should result in better leadership among the unions and that is one of the things needed at all times."

Post-Graduate Work

In the suggested outline of a course in construction engineering, there is also indicated a fifth and sixth year of training—this being a matter of choice on the part of the student.

The fifth year might be the program of subjects outlined for the sixth year, or more preferably, it should be a year of experience on a construction job in the form of an "internship." This year should be devoted to employment in any capacity that is obtainable. Employment as a laborer, chainman, rodman, or on some menial position out on the job should not be under-estimated for its advantages. If, as a result of summer employment, the student has already demonstrated qualifications for being employed on more advanced work, and has the opportunity to land a job in it, so much the better.

If the student is willing to take such a year of "internship" and plan his next, or sixth year, to return to school for advanced training, he will derive important benefits. Among these are the following:

(*a*) In the succeeding year in school, he can shape his education in the direction which his experiences have suggested, and get a great deal more out of his final year in school.

(*b*) If he finds during the internship that he is not in the right branch of construction to meet his interests, he can leave at the end of the year without prejudice and upon completing the succeeding year at school, enter with advanced standing in his chosen line of work.

(*c*) He has the opportunity to look over his new employer and the employer has a similar opportunity to observe the student. At the end of the year, if it is mutually agreed to not resume employment, this has been arrived at without the usual casualty which occurs at about this time if the employer has become dissatisfied with certain performances. The employer, as a matter of fact, may be in a position to advise the student what he ought to do following his return to school, and thus contribute to a better future. On the other hand, if the student has demonstrated himself to have abilities which the employer wants to keep, the latter can readily make an offer of re-employment.

The subjects suggested for the sixth year (fifth college year) are of an advanced nature as listed in the table.

and their suitability for training of men interested in the construction field is, no doubt, obvious. Upon completion of that year, the student would receive a degree of "Master of Science in Civil Engineering (Construction)."

Since a thesis is required for the Master's Degree, the year of "internship" provides an ideal time for writing such a thesis describing the project on which the student is employed. In fact, it would be desirable to establish, as a *requirement* of the "internship," the presentation of a thesis on the year's experience. Such a thesis can have considerable value for the student as well as for the employer. For the student, it demonstrates his capacity for observing what is going on, and shows his understanding of methods and job policies. He can make a general analysis of job procedures in terms of the principles which he has learned during the preceding four years. On the basis of such a study made first hand, the employer will invariably find valuable suggestions which will benefit his own organization, and provide concrete evidence regarding the suitability of the student for potential future employment.

No doubt, a majority of the students would have a variety of reasons for not returning to college for another year after having tasted "liberty," "income," or "love" following their graduation. However, those who have the determination to follow through on the plan here suggested, will find that their chances are substantially improved for capitalizing on their educational investment. At the outset they are in a much better position to sell their services because they have had some seasoned "experience" and know what the employer wants.

Introduction of New Course in Present Civil Engineering Colleges

As has already been stated, it is impossible to set up a so-called model course which might be made readily adaptable for several different civil engineering colleges. It appears that no two colleges are organized alike, and the best that can be hoped for is that those colleges which are most interested take such first steps as are feasible within their present limitation. One noted educator in this field has suggested the following three alternatives for getting started:

1. Emphasize construction procedures in regular civil engineering courses. Many present courses of design take account of Construction Methods for best results. "A closer association of design and construction in our present courses offers another approach to better education in construction engineering."
2. Establish construction options in present civil engineering curicula. This is feasible in the larger schools where enrollment is big enough to make such a sub-division economical. (In the opinion of the writer, this is the most desirable step.)
3. Establish curricula which would lead to a degree in Construction Engineering. This would only be feasible in the largest schools.

Whenever the subject of engineering curricula is discussed among progressive educators and practicing engineers, the suggestion is made that engineering courses be at least five or six years long, and that the first four years should provide a basic training

which would be the same for civil, mechanical, and electrical students. This would provide for broader treatment of each undergraduate subject and the introduction of more fundamentals in each field. At the end of the fourth year, a degree of Bachelor of Science in Engineering would be granted. The specialized field of work would be offered in the fifth year. (Some advocate two years of specialization.) The writer heartily concurs in this general principle and is hopeful of some day seeing all engineering curricula lengthened to five years. However, most educators seem to feel that this would require concerted action on the part of all schools and no one seems to be willing to take the first step. By the same token, the introduction of a *new* sub-division in present under-graduate courses meets some objections because it is going contrary to the most desirable trend.

It might be added here that although the four year basic training course might offer the students the opportunity to postpone their decisions as to the field of specialization, the writer has found from interviewing several thousand college seniors in engineering that those who know what they want by that time make the best prospects for the future. Furthermore, it should be borne in mind that the five or six year course in effect exists now in terms of post-graduate work for any student who displays the necessary initiative in designing his own technical education and engineering career.

How to Get Started

Conditions in the construction industry are such that the need for a greater percentage of technically trained men exists now. A limited number of colleges should therefore start in right now to meet that demand. The first step is for a college administrator to employ an experienced construction man interested in the training of young engineers to serve as Professor of Construction Engineering, and allow him to build up a program. It will take him several years to work out the details but at least the work will be under way. The first step of selecting such a man is in itself of sufficient importance to incur some loss of time. Some retired contractors or superintendents may find this an appealing opportunity. "Each professor will in his own way organize his material and properly classify the subject matter which pertains to construction engineering so that it will fit into the general pattern of a basic science and contribute to the fundamental methods of mental training." To this should be added the highly important values which are contributed by an experienced construction engineer and builder of men, who through his personal qualities serves as an inspiration for the student; this remains long after much of the basic subject matter is forgotten.

Basic Qualitative Thermodynamics

By ERNEST M. FERNALD

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Two beliefs especially underlie this article: (1) that physical concepts should be clear qualitatively, in advance of and quite apart from mathematical formulations; and (2) that qualitative formulations may be in good or in poor harmony with the essential character of the subject. Current expositions of thermodynamics exhibit departures from both requirements. Basic definition of entropy through $dS = (dQ/T)_{rev}$ is not in accord with the first, while failure to give to volume a special thermodynamic significance distinct from its common one of cubic content illustrates the poor harmony mentioned in the second, as will be shown. Of course, every division of science must develop from and in the light of its predecessors. However, when the new knowledge has been won it is usually well to organize it into a harmonious structure which takes its shape from the new point of view, regardless of historical or other considerations. The present article sets forth basic concepts for classical thermodynamics accordingly. The primary elements are deemed to be matter and energy and the two modes of energy transfer *heat* and *work*.

Indicative of room for improvement in past and current thinking is the definition of energy given in so many physics texts and courses—that energy is the capacity for doing work. Under this definition, capacity to do work is invariant under the First Law while it steadily diminishes under the "degradation" version of the Second Law, all this commonly appearing in the same book. Capacity to produce effect is a better definition; if one must specify further, capacity to produce thermal effect—certainly not mechanical.

The conventional First and Second Laws are not enough where the point of view takes in both energy and matter. More satisfactory is the following set of six generalizations, three concerning quantity and three concerning trend.

QUANTITY.

1. Quantity of matter is constant.
2. Quantity of energy is constant.
3. Ratio of energy to matter is finite.

TREND

4. Matter tends toward concentration.
5. Energy tends away from concentration.
6. Change as a whole is irrevocable.

Of these, 1 and 2 are the ordinary laws of conservation, 3 seems to be taken for granted, and 4 is the law of gravitation. Number 6 appears to be an adequate rendering of the Second Law, in philosophical rather than engineering terms. Impossibility of perpetual motion of the second class—

currently a favorite version of the Second Law—goes along with it. A perpetual motion machine, second class, could exactly revoke change in any limited portion of the universe—could undo effects of friction, restore unequal temperatures, raise fallen weights. By successive applications of the machine, all change could theoretically be revoked in the whole physical world. Whether we elect to postulate the impossibility in engineering or in philosophical terms is probably immaterial. The writer's choice means merely that he feels more like a philosopher than an engineer when thinking about these matters.

Statement 5 is intended to cover radiation and what the writer has called in an earlier article [1] the law of stability. The article pointed out that bodies are stable with respect to reversible transfer of energy, in the sense that reversible addition of energy through any mode of transfer acting alone results in added resistance to taking in more. Some property recognizable as the potential for the mode rises in opposition, as does temperature when energy is added exclusively as heat, and pressure when energy is added exclusively as work. Exception must be made for three phases in equilibrium at a triple point. That the trend of energy is away from concentration, then, is attested by universal radiation and by resistance to continuous addition of energy through any one avenue. This becomes especially clear when it is noted that the opposite is true for matter. The greater the concentration of matter, the greater the force promoting it. But the greater the concentration of energy, other things being equal, the greater the opposition.

Unfortunately, in a second article [2] the writer supported the thesis that the tendency of energy to disperse is adequate to serve in place of the common Second Law. The fact is that the particular phenomena leading to the dispersion postulate—radiation and stability—could exist equally well in a world admitting perpetual motion of the second class as in one which does not admit it. No generalization concerning either seems to affect the other, under any unstrained interpretation. Separate generalizations are required.

No matter what pressure, temperature, and volume may signify in common experience or in mechanics, their basic thermodynamic significance concerns energy and transfer of energy. For example, it is important from the standpoint of thermodynamics whether energy will be transferred between two particular states as work or as heat, and in which direction. The ideas of work-potential and heat-potential thus arise. Thermodynamic experience here may be expressed qualitatively as follows.

Two bodies are at the same work-potential or heat-potential when no energy passes by the corresponding mode of transfer when they are placed in direct contact or its equivalent. When two bodies are not at the same potential, that of the body giving energy to the other on contact shall be designated as the greater.

This covers the qualitative aspect of potential in energy transfer. Appli-

[1] Fernald, E. M., "Which Properties Are Sufficient to Determine Thermodynamic State?" Jl. Eng. Ed., XXIX, No. 10, June, 1939.

[2] Fernald, E. M., "The Second Law of Thermodynamics." Jl. Eng. Ed., XXXIII, No. 3, November, 1942.

cation of the number system is a quite distinct operation. Whether we shall set work-potential, for example, equal to pressure or to some complicated function of pressure is actually a matter of choice—of free choice if one reckons inconvenience as no constraint.

The thermodynamic significance of volume has been insufficiently emphasized. Its ordinary significance of cubic content is irrelevant in pure thermodynamics. What matters there is bound up with energy and the modes of transfer *heat* and *work*. Relative location of states is important. It is thermodynamically noteworthy, for example, when states are located so that the substance can be taken back and forth through them by means of heat alone, no work being done. If they are so located, we can express the situation by means of all the foregoing words if we choose. Alternatively, we may realize that when states are so located their specific volumes are equal, and say merely that. The primary thermodynamic significance of volume is accordingly contained in the following.

Two states so located that they can be reached reversibly from each other by means of heat alone have equal specific volumes.

This obviously suffices for the field of normal states.

A corresponding situation arises with respect to the other mode of energy transfer, work. What shall we say about states which can be reached from each other by means of work alone? To describe this situation we may either use the complete statement or adopt a single word to replace most of it. We actually thus use, of course, the word *entropy*. An adequate qualitative idea of entropy is simply this:

Two states so located that they can be reached reversibly from each other by means of work alone have equal specific entropies.

This also suffices for the field of normal states.

The mathematical scale for entropy is open to choice. For a single substance, an arbitrary scale might do fairly well. It is the choice of $dS = (dQ/T)_{rev}$ that permits the convenient generalizations and important deductions familiar to us. With that equation adopted, changes of entropy in reversible heat transfer are necessarily equal and opposite, total entropy necessarily increases in irreversible heat transfer, values of entropy can be assigned to unstable states not reachable from all directions, chemical change can be readily dealt with, etc. Parallel to $dS = (dQ/T)_{rev}$ is the equation concerning volume, $dV = (dW/P)_{rev}$. Few ever use it, because the common idea of volume is so familiar and convenient. To that extent, we ordinarily do not think in thermodynamic terms, do not come fully to a thermodynamic point of view. Apparently, no important writer has ever done so. Those who wish to amuse or inform themselves by thinking entirely in thermodynamic terms can parallel every relation concerning entropy by a corresponding relation concerning volume. Unavailable energy equal to $T_0(S_2 - S_1)$ can be balanced by unavailable energy equal to $P_0(V_2 - V_1)$, where T_0 and P_0 are the temperature and pressure of the atmosphere, and so on.*

It is hoped that the foregoing paragraphs will draw attention to the purely

* See, for example, Fernald, "Elements of Thermodynamics," McGraw-Hill, 2nd ed., 1938, pp. 284–287.

thermodynamic point of view and will promote its use in thermodynamics. The most conspicuous result of thinking along the lines indicated is a considerable deflation of entropy. Entropy has long been a prime mystery, quite unnecessarily so from the point of view urged here. Pressure and entropy, temperature and volume, are envisaged as corresponding pairs in a symmetrical structure based on work and heat, each concept being qualitatively defined for thermodynamics in terms of energy, work, and heat. The qualitative scheme indicated is adequate and uniformly simple, and appears to be outstandingly in keeping with the subject.

Achievement Tests in Mechanics*

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Introduction

This report is the second one to be made on the study of Achievement Tests in Mechanics, a study which is financed by the Society and carried out under the sponsorship of the Division of Mechanics.

The first report † was made a year ago and contains details of the inauguration of the program. In June, 1942, the Division voted to continue the study for another year and at that time a number of persons made the request that their institutions be allowed to coöperate by giving the tests. While an effort was made to reach all of those whose names were given to me I failed, as I learned later, to get in touch with the proper person in a few cases. Some of the institutions which assisted last year were unable to do so this year but on the whole there was hearty coöperation in the study. The following institutions, through the persons named, have assisted by giving the tests: Purdue University, Seibert Fairman; Ohio State University, Samuel B. Folk; Illinois Institute of Technology, Charles O. Harris; University of Nebraska, C. M. Duff; Kansas State College, Frank McCormick; Texas Agricultural and Mechanical College, V. M. Faires; University of Illinois, Fred B. Seely. My thanks are extended to all of these institutions and men for their helpfulness. I wish also to record my thanks for the assistance which was given by Rex L. Brown, Associate in Theoretical and Applied Mechanics, University of Illinois, who scored all the papers and made many helpful tabulations of the results. His work was of great assistance to me in analyzing the data.

Objectives

At the meeting last year the desired objectives of the study were discussed. It was agreed that the objectives should be, primarily, to develop a minimum achievement test, one which would indicate whether a student possessed sufficient knowledge of statics to allow him to proceed to the next subject in his course of study and, second, to serve as a means of classifying students according to their achievements. The effectiveness of any test must be judged by a standard and in building such a test it seems inevitable that the standard should be the grade given in the course, this grade being made up of a number of elements not the least of which is the personal knowledge of the student by the instructor. Furthermore, any grade established by the instructor is made up to some extent of non-factual and non-analytical elements

* Presented at the 50th Anniversary Meeting (Mechanics) S.P.E.E., Chicago, Ill., June 18–20, 1943.

† "Progress Report on Achievement Tests," Jasper O. Draffin, *Jour. Eng. Educ.*, Vol. XXXIII, No. 3, 1942, pp. 228–234.

such as promptness, alertness, and dependability. Obviously an achievement test, which is factual and analytical in character, cannot be expected *per se* to agree completely with the grade which is made up partly of the non-factual and non-analytical elements.

The Tests

While there are many superficial differences in the content of statics as taught at various institutions there is still a basic body of material, which is covered in all textbooks, with which all qualified students of the subject should be familiar. Briefly this basic content includes a knowledge of the magnitude and location of the resultants of force systems, of the moments of forces, of the equilibrium of two-force and three-force members, of centroids and of simple problems in friction. These topics are the ones on which the questions in the Achievement Tests were based.

Each question was selected from those submitted by various instructors at a number of institutions and two tests, *C* and *D*, were framed to satisfy the following conditions: (1) The computations must be simple; (2) the questions must be of nearly equal difficulty; (3) there must be but one answer and where the question is of the multiple-choice type the correct answer must be distinctly different from the other values given; (4) each test must be capable of solution in a period of 50 minutes. After a tentative selection and formulation of questions, both tests, *C* and *D*, were read critically by an instructor who had no part in writing them. The criticisms were then considered and the questions rewritten. Test *C* has 20 questions and Test *D* has 10 questions.

Results

General Considerations.—In the first place it must be remembered that there are differences in: (1) Individual students; (2) groups of students at the same institution; (3) groups of students at different institutions; (4) standards at different institutions; (5) standards of different instructors, and (6) objectives of different instructors and institutions. In short, there are manifold differences which cannot be reconciled by or included in any short-time test. I am not saying that this is not proper or desirable but merely that it exists.

Perhaps this is a good place to say that the feeling has been widely expressed, especially before the test was given, that the Achievement Test is not searching enough, not sufficiently comprehensive. The feeling exists that the Achievement Test may demonstrate the ability of the student to answer correctly a series of short questions but that it does not necessarily demonstrate his ability to carry through to a final solution a problem which involves a number of steps. In other words, the Achievement Test is generally considered as being too easy. It must be admitted that the lack of a requirement that the student make some comprehensive analysis is an inherent limitation in any short-time, easily-scored test and this is unfortunate. The results however do not furnish any real justification for the conclusion that the Achievement Tests which were used were "easy."

The general information on the tests is given in Table I. The course in statics is usually given in the second semester of the sophomore year, though a number of institutions schedule it in the first semester of the junior year

TABLE I

GENERAL AVERAGES

Institution Number	Approximate Weight of Tests in Final Grade, Percentages	Number of Papers	Average Grade	
			Test *C*	Test *D*
1	*	191	65.8	45.0
2	27	135	72.1	59.0
3	*	325	—	40.0
4	*	59	65.6	—
5	4–7	83†	—	47.2
6	10–13	104	—	64.0
7	*	66	—	51.6
All		963†	67.9	47.9

* Little or no assigned weight given to the tests.

† This institution gave Test *D* to a second group of 82 students too late to be included in the analyses.

for a part of their students, and it is the equivalent of 2 hours per week per semester. In some cases it is combined with kinetics and in others it is separate.

Most institutions preferred to use Test *D*. This decision was perhaps dictated by conditions growing out of the war situation but I cannot but feel that it was unfortunate that both tests were not used since the two seem to have a better predictive value for high-grade students than either alone. It will be noted that there is a wide variation in the weight given to the score of the Achievement Test in determining the grade in the course, a number of institutions giving it no assigned weight.

There are three phases in the analysis of the results which need to be considered and these phases may be stated in the form of questions as follows:

(1) How does the Achievement Test separate those students who have achieved minimum standards from those who have failed to do so, judged by the grades assigned to them in the course at the different institutions?

(2) How well does the Achievement Test measure the mental achievement of the student as judged by the grades assigned to him in the course?

(3) How well do the individual questions serve to differentiate between high-grade and low-grade students?

Distribution of Grades.—Table II shows the percentage of each of five grades, *A*, *B*, *C*, *D*, and *E*, assigned by each institution and the average for all institutions. As might be expected there is a wide variation in the percentages of each grade at the various institutions, for *A*, from 5.8 to 14.8; for *B*, from 16.0 to 31.9; for *C*, from 24.1 to 49.1; for *D*, from 13.6 to 28.3; and for *E*, from 6.8 to 27.4. If these differences are due entirely to the quality of the students, the Achievement Test results should run parallel to these values, which they do not do.

Correlation of Test Scores with Grades.—Table III shows another aspect of variation. It gives the average Achievement Test score at each institution for all the students receiving a given grade. For instance for Test *D* in Institution No. 3 the average score

TABLE II

PERCENTAGES OF VARIOUS GRADES IN COURSE ASSIGNED BY DIFFERENT INSTITUTIONS

Institution Number	Number of Papers	Grade				
		A	*B*	*C*	*D*	*E*
1	191	7.3	17.8	33.0	28.3	13.6
2	135	14.8	31.9	24.4	16.3	12.6
3	325	5.8	16.0	31.4	19.4	27.4
4	59	8.5	22.0	49.1	13.6	6.8
5	83	9.6	25.3	24.1	25.3	15.7
6	104	10.6	17.3	32.7	21.1	18.3
7	66	6.1	27.3	34.8	22.7	9.1
All	963	8.4	20.7	31.6	21.3	18.0

TABLE III

AVERAGE NUMBERS AND SCORES OF STUDENTS IN EACH OF FIVE GRADES

TEST *C*

Grade		Institution Number			
		All	1	2	4
A	No. Stud.	40	15	20	5
	Score	83.8	83.3	84.0	85.0
B	No. Stud.	89	33	43	13
	Score	74.8	74.2	76.7	70.0
C	No. Stud.	124	62	33	29
	Score	67.2	67.9	68.5	64.5
D	No. Stud.	84	54	22	8
	Score	60.9	60.0	65.7	53.7
E	No. Stud.	48	27	17	4
	Score	57.6	54.8	61.8	58.7

TEST *D*

Grade		Institution Number						
		All	1	2	3	5	6	7
A	No. Stud.	76	14	20	19	8	11	4
	Score	71.4	77.1	88.0	56.3	75.0	74.5	60.0
B	No. Stud.	186	34	43	52	21	18	18
	Score	56.1	55.6	64.7	50.0	53.3	65.0	51.7
C	No. Stud.	275	63	33	102	20	34	23
	Score	47.7	44.8	52.1	40.7	47.0	62.1	56.6
D	No. Stud.	197	54	22	63	21	22	15
	Score	42.1	39.8	50.5	38.0	37.6	52.7	43.3
E	No. Stud.	170	26	17	89	13	19	6
	Score	33.5	27.3	37.6	32.2	34.6	42.1	48.3

for 19 students receiving the grade of *A* was 56.3 while in Institution No. 2 the average score for 20 students was 88.0. It seems strange that so many students of *A* grade should score so poorly on an entire test (not merely on a single question) of this character. There seems to be only a reasonable variation between institutions on Test *C* but only three institutions gave this test.

The variation in the score on the Achievement Test and the grade in the course is shown in detail for the various institutions in Table IV. It will be noted that no student writing Test *D*

who received a grade of *E* in the course made a score in excess of 70 but that a number of those who received a grade of *A* scored very low. The assignment of a grade of *E* for a student scoring rather high in the Achievement Test may be justified on the ground that he did not fulfil other necessary requirements but it seems more difficult to understand, barring illness or unusual circumstances, why an *A* student should be unable to answer such a large proportion of the questions on Test *D*. This statement does not imply that I have any criticism to make of the grades assigned, it merely means that I am calling these anomalies to your attention. It should be said, however, that some instructors feel strongly that many students do poorly on an examination of a type to which they are not accustomed.

It was stated earlier that Tests *C* and *D* together furnish a somewhat better criterion of high achievement than either test does alone. Only two institutions gave both tests but since there were 325 students involved there should be a fair degree of reliability. The data are shown in Table V where, instead of the five grades, the division is into three groups: High, *A* and *B;* average, *C* and *D;* and failure, *E*.

It will be noted that four persons in the high group made scores of 41–50 but that none who received a failure

TABLE IV

NUMBER OF STUDENTS WHOSE SCORE ON THE ACHIEVEMENT TEST FELL IN THE LEVEL INDICATED

TEST *C*

Grade in Course	Inst. No.	Score									
		15–20	25–30	35–40	45–50	55–60	65–70	75–80	85–90	95–100	Total
A	1	0	0	0	0	0	3	3	5	4	15
	2	0	0	0	0	0	2	6	9	3	20
	4	0	0	0	0	0	1	0	4	0	5
	All	0	0	0	0	0	6	9	18	7	40
B	1	0	0	0	2	1	12	12	6	0	33
	2	0	0	0	1	3	11	13	14	1	43
	4	0	0	0	0	4	1	8	0	0	13
	All	0	0	0	3	8	24	33	20	1	89
C	1	0	0	0	1	16	29	13	3	0	62
	2	0	0	0	1	9	9	11	3	0	33
	4	0	1	0	4	5	13	4	2	0	29
	All	0	1	0	6	30	51	28	8	0	124
D	1	1	0	2	8	18	22	3	0	0	54
	2	0	0	0	1	4	13	4	0	0	22
	4	0	0	3	2	1	0	2	0	0	8
	All	1	0	5	11	23	35	9	0	0	84
E	1	0	2	4	5	8	6	2	0	0	27
	2	0	0	1	2	6	6	1	1	0	17
	4	0	0	0	1	2	1	0	0	0	4
	All	0	2	5	8	16	13	3	1	0	48

TABLE IV. (*Continued*)

TEST *D*

Grade in Course	Inst. No.	Score											
		0	10	20	30	40	50	60	70	80	90	100	Total
A	1	0	0	0	0	1	1	1	2	3	5	1	14
	2	0	0	0	0	0	0	0	2	5	8	5	20
	3	0	1	1	1	1	3	7	2	1	2	0	19
	5	0	0	0	0	1	1	0	1	2	2	1	8
	6	0	0	0	0	0	1	2	2	4	1	1	11
	7	0	0	0	1	0	1	0	1	0	1	0	4
	All	0	1	1	2	3	7	10	10	15	19	8	76
B	1	0	0	0	4	3	10	7	7	3	0	0	34
	2	0	0	0	1	4	7	9	14	2	4	2	43
	3	2	0	4	6	8	12	7	7	4	1	1	52
	5	0	0	2	3	3	4	2	3	2	2	0	21
	6	0	0	0	1	2	2	4	2	5	2	0	18
	7	0	1	1	1	5	0	5	4	0	1	0	18
	All	2	1	7	16	25	35	34	37	16	10	3	186
C	1	0	4	5	5	20	11	12	2	4	0	0	63
	2	0	0	1	5	2	13	7	1	3	1	0	33
	3	4	6	15	12	22	18	16	6	1	1	1	102
	5	0	0	3	3	3	4	3	3	1	0	0	20
	6	0	0	0	2	1	10	5	8	7	1	0	34
	7	0	1	1	2	3	2	6	5	1	0	2	23
	All	4	11	25	29	51	58	49	25	17	3	3	275
D	1	0	5	8	3	18	10	8	1	1	0	0	54
	2	0	0	1	2	4	9	2	2	2	0	0	22
	3	1	6	14	9	8	13	9	2	0	1	0	63
	5	0	0	4	5	6	5	0	1	0	0	0	21
	6	0	0	0	2	6	5	4	3	2	0	0	22
	7	0	1	0	5	4	1	1	2	1	0	0	15
	All	1	12	27	26	46	43	24	11	6	1	0	197
E	1	1	4	8	5	5	2	1	0	0	0	0	26
	2	0	1	2	5	5	1	2	1	0	0	0	17
	3	3	12	15	18	19	18	3	1	0	0	0	89
	5	0	1	5	1	1	3	2	0	0	0	0	13
	6	0	1	2	1	8	3	5	1	0	0	0	19
	7	0	0	0	0	3	2	0	1	0	0	0	6
	All	4	19	32	30	41	29	11	4	0	0	0	170

made a score in excess of 70. If one were compelled, however, to rely on these tests alone, that is Test *C* or Test *D*, or a combination of the two of them, it must be agreed that they would not be very conclusive. In either *C* or *D* separately or *C* and *D* together, no matter where the line is drawn there would be a number of students who would be excluded who should pass and a number included who should not pass. Of course this situation is accentuated by the apparent lack of uniformity of grades in the

TABLE V

NUMBER OF STUDENTS, IN EACH OF THREE GROUPS, WHO MADE THE AVERAGE SCORES INDICATED ON TESTS *C* AND *D*

Grade in Course	Inst. No.	Average Score									
		11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	Total
A, B	1	0	0	0	4	9	14	12	6	3	48
	2	0	0	0	0	8	13	20	16	6	63
C, D	1	0	1	16	29	47	18	5	0	0	116
	2	0	0	0	7	29	14	4	1	1	55
E	1	2	5	6	8	5	0	0	0	0	26
	2	0	0	4	7	3	3	0	0	0	17

different institutions. Maybe the questions are too difficult or there is not enough time allowed for a proper study of each one. Certainly the claim cannot be substantiated that the Achievement Tests are too easy. It is of interest that Institution No. 5 gave Test *D* to a group of about 80 students since the data in this report were analyzed, and the results were approximately the same as those given here.

INDIVIDUAL QUESTIONS

The next step is to study the individual questions in each test and to try to determine whether some questions, and which ones, have a high degree of correlation with the grade in the course. Similarly it is desired to find those questions which are so difficult that but few students are able to answer them. To a degree at least both of these questions, the too-difficult and the too-easy, are not satisfactory ones as a measure of achievement in the course. The correlation of the scores on each question with the grade in the course is given in Table VI. Since there are considerable differences between institutions both as to percentages and as to number of students, the averages for all institutions will furnish the best criterion of the value of the questions to differentiate between students.

In Test *C*, Questions 2, 4, 13, 14 and 15 all give low scores while Questions 1, 3, 5, 9 and 12 give high scores. Question 10 is not too high but it does not differentiate between high-grade and low-grade students. Questions 6, 7, 11, 16, 17, 18, 19 and 20 are fairly good. Similarly in Test *D*, Questions 3, 5, 7 and 9 are too low while Question 2 does not seem to differentiate. This leaves Questions 1, 4, 6, 8 and 10 of Test *D* which are, on the average, fairly satisfactory.

The scores for Questions Nos. 6, 7, 11, 16, 17, 18, 19 and 20 of Test *C* are given in Table VII and those for Questions Nos. 1, 4, 6, 8 and 10 are given in Table VIII.

It is obvious that a small number of questions makes possible many wide variations and also that as the number of papers increase there is a greater possibility of extremes in the results. These variations are especially pronounced in Table VIII where only five questions and a large number of papers are considered. The best results, from the selected questions, are those shown

TABLE VI

NUMBER AND PERCENTAGES OF STUDENTS, IN EACH OF THREE GROUPS, WHO GAVE CORRECT ANSWERS TO THE VARIOUS QUESTIONS

Percentages at Each Institution Are Based on the Total Number of Students at That Institution

TEST *C*

Question No.	Grade	Institution Number: All		1		2		4		Question No.	Grade	Institution Number: All		1		2		4	
		No.	%	No.	%	No.	%	No.	%			No.	%	No.	%	No.	%	No.	%
All	*A, B*	129		48		63		18		All	*A, B*	129		48		63		18	
	C, D	208		116		55		37			*C, D*	208		116		55		37	
	E	48		27		17		4			*E*	48		27		17		4	
1	*A, B*	123	95	43	90	62	98	18	100	11	*A, B*	118	91	43	90	56	89	17	95
	C, D	183	88	93	80	54	98	36	97		*C, D*	180	87	108	93	42	76	30	81
	E	40	83	20	74	17	100	3	75		*E*	34	71	17	63	14	82	3	75
2	*A, B*	66	51	24	50	30	48	12	67	12	*A, B*	127	98	47	98	62	98	18	100
	C, D	118	57	66	57	28	51	24	65		*C, D*	200	96	112	97	54	98	34	92
	E	28	58	16	59	9	53	3	75		*E*	45	94	24	89	17	100	4	100
3	*A, B*	118	91	45	94	58	92	15	83	13	*A, B*	82	64	35	73	38	60	9	67
	C, D	189	91	109	94	50	91	30	81		*C, D*	96	46	54	47	30	54	12	32
	E	40	83	24	89	14	83	2	50		*E*	22	46	10	37	10	59	2	50
4	*A, B*	54	42	17	35	30	48	7	39	14	*A, B*	82	64	28	58	46	73	8	44
	C, D	64	31	37	32	19	34	8	22		*C, D*	71	34	32	28	27	49	12	32
	E	12	25	9	33	2	12	1	25		*E*	15	31	6	22	8	47	1	25
5	*A, B*	117	91	40	83	61	97	16	89	15	*A, B*	64	50	21	44	34	54	9	50
	C, D	191	92	104	90	53	96	34	92		*C, D*	106	51	65	56	24	44	17	46
	E	36	75	23	85	11	65	2	50		*E*	19	40	11	41	6	35	2	50
6	*A, B*	99	77	37	77	53	84	9	50	16	*A, B*	79	61	35	73	34	54	10	55
	C, D	120	58	70	60	33	60	17	46		*C, D*	106	51	69	60	27	49	10	27
	E	19	40	9	33	7	41	3	75		*E*	23	48	15	56	7	41	1	25
7	*A, B*	107	83	36	75	58	92	13	72	17	*A, B*	118	91	39	81	63	100	16	89
	C, D	129	62	64	55	37	67	28	75		*C, D*	168	81	90	78	50	91	28	75
	E	25	52	10	37	12	71	3	75		*E*	34	71	17	63	13	76	4	100
8	*A, B*	90	70	31	65	46	73	13	72	18	*A, B*	114	88	43	90	55	87	16	89
	C, D	94	45	53	46	25	45	16	43		*C, D*	171	82	97	84	45	82	29	78
	E	21	44	9	33	10	59	2	50		*E*	32	67	18	67	12	71	2	50
9	*A, B*	124	96	47	98	61	97	16	89	19	*A, B*	106	82	35	73	54	86	17	95
	C, D	187	90	107	92	47	65	33	89		*C, D*	114	55	58	50	31	56	25	67
	E	38	79	20	74	14	82	4	100		*E*	24	50	13	48	9	53	2	50
10	*A, B*	100	77	42	88	47	75	11	61	20	*A, B*	95	74	33	68	47	75	15	83
	C, D	129	62	73	63	37	67	18	49		*C, D*	88	42	40	35	28	51	20	54
	E	33	69	18	67	13	76	2	50		*E*	14	29	7	26	5	29	2	50

TABLE VI. (*Continued*)
TEST *D*

Question No.	Grade	Institution Number													
		All		1		2		3		5		6		7	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
All	*A, B*	261		48		63		71		28		29		22	
	C, D	475		117		55		167		42		56		38	
	E	168		26		17		87		13		19		6	
1	*A, B*	199	76	42	87	52	82	46	65	20	71	27	93	12	55
	C, D	327	69	68	58	37	67	117	70	34	81	44	79	27	71
	E	88	52	10	38	7	41	45	52	9	69	14	74	3	50
2	*A, B*	220	84	39	81	56	89	59	83	23	82	25	86	18	82
	C, D	368	77	83	71	34	62	140	84	36	86	48	86	27	71
	E	118	70	17	65	9	53	63	72	11	84	14	74	4	67
3	*A, B*	117	45	19	40	37	59	30	42	13	46	14	48	4	18
	C, D	125	26	17	15	18	33	43	26	13	31	19	34	15	40
	E	33	20	3	12	3	18	21	24	2	15	2	11	2	33
4	*A, B*	201	77	43	90	57	91	37	52	21	75	25	86	18	82
	C, D	278	58	90	77	41	75	58	35	20	48	42	75	27	71
	E	76	45	12	46	11	65	29	33	3	23	17	89	4	67
5	*A, B*	90	35	13	27	35	56	15	21	6	21	14	48	7	32
	C, D	66	14	12	10	16	29	18	11	1	2	14	25	5	13
	E	12	7	0	0	5	29	2	2	0	0	3	16	2	33
6	*A, B*	153	59	21	44	52	82	30	42	15	54	20	69	15	68
	C, D	184	39	39	33	35	64	43	36	10	24	34	61	23	61
	E	37	22	4	15	4	24	18	21	5	37	2	11	4	67
7	*A, B*	128	49	20	42	34	54	37	52	14	50	15	52	8	36
	C, D	107	25	13	11	15	27	53	32	7	17	9	16	10	26
	E	27	16	2	8	6	35	14	16	0	0	3	16	2	33
8	*A, B*	166	64	33	69	46	73	33	46	20	71	20	69	14	64
	C, D	206	43	60	51	21	38	38	23	19	45	43	77	25	66
	E	49	29	5	19	7	41	18	21	4	31	10	53	5	83
9	*A, B*	131	50	24	50	41	65	33	46	13	46	14	48	6	27
	C, D	180	38	44	38	26	47	53	32	14	33	28	50	15	40
	E	41	24	4	15	2	12	29	33	2	15	4	21	0	0
10	*A, B*	192	74	40	83	44	70	46	65	22	79	25	86	15	68
	C, D	294	62	71	61	37	67	94	56	25	60	46	82	21	55
	E	87	52	11	42	10	59	41	47	10	77	12	63	3	50

in Table IX which is a combination of Tests *C* and *D* for the two institutions which gave both tests. While there are some high-grade and average students who made very low scores and some low-grade students who made

good scores it does not seem that there are many more extreme cases in these scores than might occur in any final examination covering the same number of papers. If this conclusion is justified it is one of the most satis-

TABLE VII

NUMBER OF PAPERS AT VARIOUS AVERAGE SCORES, BASED ON EIGHT QUESTIONS OF TEST *C*, FOR EACH OF FIVE ASSIGNED GRADES

Grade	Number of Papers	Score								
		12	25	37	50	62	75	87	100	Av.
A	39	0	0	0	2	0	9	14	14	87.0
B	90	0	0	5	5	14	16	36	14	78.3
C	124	0	3	8	18	30	37	22	6	66.3
D	84	1	3	11	25	20	15	9	0	58.6
E	39	2	3	8	6	6	8	5	1	56.7
Total	376	3	9	32	56	70	85	86	35	

TABLE VIII

NUMBER OF PAPERS AT VARIOUS AVERAGE SCORES, BASED ON FIVE QUESTIONS OF TEST *D*, FOR EACH OF FIVE ASSIGNED GRADES

Grade	Number of Papers	Score						
		0	20	40	60	80	100	Av.
A	78	1	1	8	8	29	31	80.0
B	184	4	9	26	60	60	25	65.9
C	272	15	31	56	79	65	26	56.6
D	198	11	28	51	58	40	10	51.9
E	160	14	49	39	38	17	3	40.5
Total	892	45	118	180	243	211	95	

TABLE IX

NUMBER OF PAPERS WRITING VARIOUS SCORES, BASED ON THIRTEEN QUESTIONS FROM TESTS *C* AND *D*, FOR EACH OF FIVE ASSIGNED GRADES

Grade	Number of Papers	Scores													
		8	15	23	31	38	46	54	62	69	77	85	92	100	Av.
A	34	0	0	0	0	0	0	0	1	2	2	8	17	4	88.2
B	77	0	0	0	0	0	3	3	8	18	10	23	9	3	76.3
C	95	0	0	0	0	3	9	17	16	22	11	14	3	0	65.7
D	76	0	0	1	3	7	8	18	15	15	6	2	1	0	58.0
E	43	1	3	2	4	7	8	3	7	3	4	1	0	0	47.7
Total	325	1	3	3	7	17	28	41	47	60	110	48	30	7	

fying in the whole study because it seems to indicate something of the number and type of questions needed.

Conclusions

(1) The results are rather disappointing but they substantiate in a general way the results of last year's work.

(2) There is a widespread feeling among instructors that tests such as those used here are not sufficiently comprehensive, that they do not test the ability of the student to handle anything but the simple cases. The test results do not seem to entirely justify this feeling.

(3) The percentage of each of the five grades assigned by the different institutions varies greatly.

(4) There is evidence that certain topics receive more attention at some institutions than at other institutions. The topic of resultants scores poorly at all institutions.

(5) The average scores at the different institutions vary a great deal; for Test *D* there is a variation of 16.5 per cent below and 33.6 per cent above the mean.

(6) An astonishingly large number of students are unable to answer correctly a reasonable number of simple questions. Many high-grade students are in this category.

(7) Certain questions appear to be definitely satisfactory while others are not satisfactory.

(8) There seems to be considerable likelihood that a better test than those used so far can be built up on the basis of Tests *C* and *D*.

Economics and Engineering Education*

By D. O. BOWMAN
University of Michigan

Professor A. I. Peterson's able paper in this JOURNAL † set forth levels of problems through which the engineer, as an engineer in technical practice, moves. Starting with the initial stage where the engineer deals with problems of design and operation, Professor Peterson then described the next two stages of quantitative resolution of problems of technical enterprises and the analysis of growth and performance of industries and public works, finally moving to the problems besetting an entire economy. The successive stages were characterized by progressively larger and more complex intellectual areas. This paper is to be regarded as an addendum to that of Professor Peterson, and is presented by one whose training and work has been in General Economics and related fields.

The purpose of this paper is twofold: (1) To indicate that in the analysis of the theoretical price structure—the most important function of General Economics—the method is similar to (perhaps identical with) that employed in Engineering Economics; and (2) To outline the substantive content of General Economics and thereby indicate that the engineer, as such, might well be familiar with more than a smattering of General Economics. Implicit throughout the concern is with training persons so that they can better perform the engineering functions of a higher level.

A moment's reflection will quickly lead to the perception that there is scarcity in services and resources (land, labor capital) relative to wants. It is apparent, then, that economizing is necessary; that there is a problem of allocating to the competing wants the available services (in whatever form such services appear) and the resources from which services flow.

Whether society organizes itself on a basis of private or social ownership of resources, there is always the problem confronting the community as to which consumers get which services and in what quantities, in which direction are the resources to be spent, how much of present production shall be immediately consumable and how much devoted to future production of services, etc. In the absence of completely irrational determination, such decisions (choices) must be made on the basis of alternatives, which is to say value judgments. The mechanism by which allocation is accomplished is the price (value) system and the study of General Economics is a study of that price mechanism. Demand, supply, and price are the elements of this field of study.

* Presented at the 50th Anniversary Meeting (Engineering Economy), S. P. E. E., Chicago, Ill., June 18–22, 1943.

† New Series, Vol. XXXI, No. 9, "Economics in Mechanical Engineering."

With the price mechanism as the focal point, the economist develops systems through progressive stages. Consumption, distribution, and production are really segments of the price universe, and in each segment the economist employs the principle of choices (values) in light of a series of alternatives. The "time-value of money" principle (as it is sometimes expressed by engineers) is accepted not because money itself has any but functional (in the exchange sense) value over time, but because by the use of monetary symbols society has a mechanism with which to measure alternatives in order to make choices as between projects. Purchase prices (in monetary terms usually) are, of course, the discounted sums of anticipated flows of future services (from, for example, a pair of shoes or a new turbine). This is true for both private and social projects and calculations regarding them.

The field of consumption is really a study of the consumer's activity when he is confronted with the necessity of making choices. The problem is one of choosing as between competing alternative lines of expenditures, and the consumer seeks to make alternatives equivalent in costs, which is to say that through substitution of one alternative for another he equalizes the rate of return for anticipated incremental expenditures. For the consumer, the rate of return, however measured, is in some desired service, such as, say, the shelter provided by housing, a train ride, or the satisfaction acquired from the consumption of food. Insofar as the consumer cannot recognize discreet alternatives his own economy is irrational and subject to the dictates of chance. There are almost no consumers completely devoid of rationality patterns in the real world, although it is a pleasant intellectual pastime for consumers to regard others, both near and far, in the income range, as irrational in their choices.

Production and distribution have their origin in and receive their guidance from the activities of the consumer. The flow of services desired by the consumers are provided by the producing units, which vary in size and organization. There is employed here, too, the operation of the alternative and choice principle in the combination, by the producer, of unlike productive factors (land, labor, capital). Guiding and ruling possible combinations (*i.e.* alternatives) in the producer's quest to obtain the minimum cost* is the value (cost) principle, which leads to an unending series of combinations of substitutable (in varying degree) factors until the producer reaches the margin of indifference. At that margin the rates of return on all possible lines of expenditures are equal and the producer therefore has the best combination—*i.e.*, he has achieved the minimum cost combination. "Functional distribution" as reflected in receipt of income over and beyond the transfer of capital is performed as production occurs through factor combination. As the producer buys factors (resources), the owners of units of those factors receive their values, which are cost to the producer. Those payments are used to purchase alternative flows of services and the system is complete. Thus, General Economics employs the minimum-cost principle (or if you like, the competing alternatives and choice as dictated by

* Leon Henderson is said to be the originator of the very apt and economic statement that, "One man's price is another man's cost."

value judgments) in consumption, in the broader fields of production and distribution, and in the economy as a whole. Equivalency of rates of return in consumption and production means that in the production process the economy automatically tends to equalize and maximize the rate of return (services) from its resources, and the societal choices necessary to direct the use of resources, the distribution of values, present vs. future services, etc., are made through the market and price mechanism.

The theoretical structure here erected, as in engineering systems, is not without flaws. Unpredictables and imponderables do enter and the free economy has no directing mentality that can introduce the engineering safety factor. But in its broad outlines the structure does exist, it does operate although with varying speeds, and economists are striving to discover its "bugs." The engineer needs to understand such a system, and its study ought to be regarded as an extension and a continuation of his Engineering Economics and his engineering education.

The belief that General Economics is a hodge-podge of "social concepts" is understandable, for in the process of allocation it is continually being discovered that different segments of society have different ends to be attained. And, indeed, many of society's functions and ends are not easily, or in some instances not at all, reducible to value (dollars) treatments. Here, too, there is often misunderstanding because individuals confuse logically their private economy with economy as it appears in the aggregate, and there is a failure to realize that a line of reasoning on an individual economic problem can seldom be applied to the forces of an entire economy.

Price economics, which is to say "scarcity" economics, is annoying to the engineer because it appears that Economics is not "practical" and that "it is not exact" because it deals with "human nature." Economics, of course, is no more trade schoolish than is engineering properly conceived. If in a course in Economics the student were to be taught how to write checks, such training would be in the same intellectual category as teaching a student engineer how to do wood work in the shop. In reality, every engineering faculty regards as most fundamental and basic the development of the student's intellectual processes and his analytical techniques—that is, training in abstract thinking and scientific method. Although the factors and subject matter differ, in both economics and engineering there is induction, deduction, conclusions based upon experience, and reasoning from assumptions. (Are not engineers often labelled "Assumption experts"?) To say that economics is not exact only indicates that the number of variables in economics renders the problems difficult and the conclusions more "if" in character. An allegation of inexactness indicts any scientific effort, and such an indictment should be made with caution. The writer, for example, has been told by both graduate and student engineers that economists should settle upon a new unit of measurement, since the dollar varies in value significance over time. Apart from the fact that the economist did not invent the "dollar," and in any event has no right to impose a "unit of measurement" on the economy; apart, too, from the fact that the dollar is but a symbol of generalized purchasing

power and therefore itself shifts in value even while functioning to reflect value judgments of goods and services, there is as much reason in the employment of the "dollar" as a measuring unit as there is reason for the employment of "measuring units" in other fields. The meter, the gram, the foot-pound, the decible, the watt, the B.T.U., the h.p. and the r.p.m. are as arbitrary and *ex definitione* as a legislative enactment defining the dollar as 13.7 grains pure gold. The important focus in all fields is on approach, relationship, and classification, not on the symbols and language used.

True, the conclusions reached in economics do depend upon human beings selecting one alternative rather than another, but generalizations can be empirically determined and variations can always be handled by assumption. Even where group or individual actions cannot be empirically determined it does not follow that all is hopeless; rather, there is a range of possible problems and possible solutions. It *is* incumbent upon the economist to select the bases of reasoning (assumptions) with care, for the logic displayed is secondary in difficulty and importance to such selection. But this methodological problem is not unique to economics; it is met with by all who use logic.

Beyond the logical method and analytical techniques which have been built up over time and which are an essential and major element in this field of study; and in a way separate from the necessity of learning such technique and the nomenclature of the field if one is to progress beyond Pedestrian Economics, there is in addition to the theoretical structure outlined, other important material covered in General Economics.

One prominent problem is, of course, the periodic paradox of goods being unavailable in the midst of unused resources—that is, the problem of unemployment of our available labor and capital, such as confronted the society in the past decade. The problem seems unreal and far away in 1943, when the difficulty is a *shortage* of resources. But the problem will occur and recur with dramatic vitality in the post-war years and may again be *the* economic problem. Study of this problem quickly engulfs one in a consideration and comparison of swings in economic activity as a whole—commonly called business cycles—and leads in turn to searching for causes. Thus one soon must consider our monetary and banking system, our savings and investment, our social and economic institutions, and indeed the whole operation of our price system. Such a study is not without its "practical" aspect; the decisions of society's leadership often hinge upon knowledge of economic events and causes, and all of society, including its business concerns and its executives, are caught in the sweep of cyclical forces. This problem is so insistent and immense that economists welcome the engineering technique where applicable, but they rightfully insist that the engineer apply the coldly objective approach rather than offer the panaceas of some political hack, who appeals to their social biases.

Another major problem is that of the relation of technology and economics, a problem hardly new but persistent. True, insofar as the engineer is responsible for technological change he is justly praised for making available greater quantities and more kinds of goods. As such activity solves certain social and economic problems, it also creates other. "The invention of

the art of invention" * has created terrific problems of economic adjustment. Technological change maladjusts the working population and brings unemployment for varying lengths of time for different groups in the economy. New devices, new methods, and different organization, often brought by the engineer, alter or destroy existing values, rupture going enterprises, render equipment obsolete, and create the need for new analyses of "technical costs," both fixed and variable. The engineer, in his analysis of particular problems where economic justification is at issue, can better solve a problem of the lower level if he comprehends the nature of the ascending levels. It was not a failure to comprehend the engineering level, but a failure to understand the higher economic level that turned technocracy, which was genuinely interested in the impact of technology, into another socio-economic Roman candle.

The world is presently engaged in a behemoth of war. When that war ceases, domestic and foreign trade patterns will have been torn down. New products, new organizations, new methods will emerge. The economy in general and the enterprise in particular is affected by the flow of trade and consequent international ties in a world that is constantly shrinking because of the efforts of the engineers. As an important cog in the economy, the engineer should comprehend the rudiments of international economics; and he should not regard his responsibility as ended when he has set the stage for a greater production flow. The "economic reality" of contemplated projects may well be determined by what are designated as "International Economics," and the fundamental relationships should be understood.

Finally, in an economy where governmental intervention and controls are expanding and changing in character the engineer should have a solid realization of the economic functions which are or can be performed by government. Even when the "agency" is established, the economic reality of possible governmental projects can be demonstrated only if the engineer is able to view government as the basic agency of the society. The provision of social security, the scope of services to be provided by government, the organizational requirements necessary to administration of government, all are subjects to which the engineering training can address itself, not only to improve the general level of knowledge but also to aid in the solution of such pressing problems.

The economist is not trained to teach Engineering Economics. That should be done by engineers. The engineers are not specialists in General Economics and persons trained in that field must instruct such courses. But as is often found, the two fields complement each other when the professional talent of each field understand the intellectual outlines of the adjoining field. Those who teach Economics and those who teach Engineering have a joint responsibility to impress upon the Engineering student that General Economics is a different but integral part of that area of his Engineering Training devoted to the development of his intellectual armor.

Discussion

K. W. Jappe (Hercules Powder Co.): Dr. Bowman's paper is a plea for economic theory as having a place

* T. N. E. C. Hearings, Technology and Concentration of Economic Power, Part 30, p. 16212.

in the background of our thinking about engineering economy. I concur. On occasion, it has a place in the foreground. It should pervade our processes. The author's suggestion that the engineer "can better solve a problem of the lower level if he comprehends the nature of the ascending levels" seems utterly sound. Perhaps the thought could be broadened and extended. We have a lot of economic illiteracy in this country. We should do something to safeguard against illiteracy of this sort among our students.

I like the stress placed on the business cycle as a focus in economic thinking. It should surely be a focus in our engineering economic thinking. This means some serious study of the separate phenomena which combine to bring about the manifestations of the business cycle. Do we not sometimes in our engineering economics work too much with patterns and too little with fundamentals? In a problem we are told to "assume" 6 per cent interest. Do our students realize that back of the assumption is a whole volume of fact and practice and philosophy, fully comparable with the body of such things which might lie back of a parallel assumption of a station economy of 16,000 B.t.u. per kw.-hr.?

Dr. Bowman recognizes amiably the value of the engineering point of view to the economist. With the mutual appreciation which this implies the two fields will in fact converge, but I wonder how many institutions give to engineering students, courses in both economic theory and in engineering economics. There would seem to be a general lack of time for this, and various compromises result, such as stress on what is called *industrial* economics. Perhaps it is arguable that the engineer in this field should learn some general economics. Of course, there is the obvious danger which arises where he doesn't learn enough of it and with sufficient thoroughness.

RUSSELL C. PUTNAM (Case School of Applied Science): At first reading the paper on "Economics and Engineering Education" by D. O. Bowman might seem to be largely of academic interest at this time because the war has upset economic values and concepts so completely. Actually, however, the importance of giving the engineering student an understanding of economic fundamentals is greater today than ever.

The engineering students who are being trained now will be among the leaders in the post-war reconstruction and development. The end of the war will find the engineer with new materials, new techniques and new and different demands. He may very possibly be confronted also with a new economic era due to the great war debt and the increased importance of the government in our economic life. The wisdom and value of his work in this new, uncharted world will depend on his understanding of economic principles as well as his knowledge of scientific and technical fundamentals.

JAMES C. CLARK (University of Arizona): Let us all be vigilant to combat, whenever it rears its ugly head, the notion that engineers are queer people; that they need special and very considerate treatment. That the notion exists is evident. Courses exist that are called "English for Engineers." The engineer is simply an ordinary cultured person with a special, and very important, function to perform in modern society. Hence, that the engineer should understand General Economics is not surprising.

That is a subject that cannot safely be slighted by anyone whose functions bring him into important relations with the leaders in society. "Doctor, lawyer, merchant, chief"; they all should be familiar with General Economics. From this point of view, it might seem that papers like those of Dr. Bowman and Professor Peterson are superfluous. Yet it must be remembered that today's engineering curriculum is extremely crowded; that it is up to every subject in it continually to justify its place. Then too, "progressive education" is rampant in the land, and who knows where it may next strike!

Dr. Bowman says "the engineer . . . can better solve a problem of the lower level if he comprehends the nature of the ascending levels." I suspect that it would be difficult to prove this, though I believe it. Going with real comprehension of the nature of the ascending levels would go the ability to handle well the problems of the lower levels. Let us look directly at the personal problem of the young engineer. Why should he deliberately ham-string his ambition, being content with the purely technical phases of engineering? If he has ability, let him aim at the highest levels of engineering work. For good performance on these levels, good General Economics is manifestly essential.

In mentioning one of the more staggeringly difficult of modern problems, Dr. Bowman says that economists welcome the engineering technique where applicable. This lends a little support to the idea held by some of the more enthusiastic engineers that "the engineer will have to get in there and straighten things out." This would certainly be engineering on the highest level. It would be necessary for the engineering "straighten-outer" that he thoroughly know his General Economics.

Dr. Bowman alleges that price economics, because it is concerned with human nature and hence cannot be exact, is annoying to the engineer. It should be noted that all good engineers learn, while still young, not to be annoyed when dealing with other human beings. It is unquestionably true that human nature is unreliable, yet only the neophyte engineer fancies that he can live serenely in a world wherein he may contemplate and calculate only physical effects. His older, wiser brother anticipates the nature of the impact of his findings upon his fellow-workers, particularly his executives. So I cannot agree that the engineer is annoyed by such a difficult intangible as human nature; on the contrary, he learns to work happily with it. If he cannot learn this, the least of his probable misfortunes is to become known as non-coöperative. If he is very non-coöperative, he will ultimately fail.

Report of Conference on English

The first meeting of the English Division was the dinner session, in the evening of June 18, at the Drake Hotel in Chicago. Presiding was Dr. J. L. Vaughan, chairman of the division. Because of the illness of the secretary, Professor Homer H. Nugent, Dr. A. M. Fountain was appointed acting secretary, and served through this and succeeding meetings of the English group.

The chief speaker for the evening was Dr. Mortimer Adler, of the University of Chicago, whose topic was "The Background for *How to Read a Book.*" As the assigned title indicates, Dr. Adler's talk was centered about the philosophies basic to the speaker's recent popular work, "How to Read a Book." Dr. Adler made it clear that his book was really a treatise on the philosophy of education, and a condemnation of present-day straight-laced educational methods. From that point, the speaker no more referred to the book, but made principally a discussion of the educational systems currently undergoing experimentation at the University of Chicago under the speaker and Dr. Hutchins, president of the university. He likewise discussed the similar but more complete system in use at St. John's College, where the speaker is a staff lecturer. Some reference was made to the educational program as set up by the army, a program which, it had been hoped, would give opportunity for additional use of the integrated system of instruction; however, the army program, as officially adopted, provided no such work.

At the end of the address, the delegates entered into a lively period of questions and discussion.

The second session of the English conference was the luncheon meeting, held at noon, June 19, at the Drake Hotel. The chief speaker of this meeting was J. S. Thompson, Treasurer of the S.P.E.E., and Vice-President of the McGraw-Hill Book Company. Mr. Thompson's paper, titled "How Can We Improve Engineering Books?," was given the subtitle "in wartime," and using that subtitle as a point of departure, was devoted to a discussion of the changes and restrictions that afflict publishers and authors in wartime. Especially important among these restrictions are those requiring smaller margins and thinner paper. The speaker illustrated this point by displaying copies of the same book in the forms in which it appeared before and after the restrictions took effect. With the changes and wartime restrictions, the book was reduced about one fourth in weight and two fifths in volume.

Mr. Thompson's paper also devoted considerable time to a discussion of the growing emphasis on illustration, and of the technical writer's eternal problem of excess verbiage and limited vocabulary.

The closing session of the conference was the afternoon meeting, held in the same room as used by the luncheon immediately preceding. The first speech was that of Edwin S. Burdell,

Director of Cooper Union. In the absence of Dr. Burdell, his paper was read by William S. Lynch, Director of Humanities, Cooper Union. His title was "The Impact of War on the Humanities Courses," and the paper dealt mostly with the effects so far felt from the 1940 report of the Committee on Aims and Scope of the Humanistic Studies. The material was based upon answers to questionnaires sent out by Dr. Burdell to seventy-five engineering schools. On the basis of returns from thirty-nine of the colleges, it seems that the report has had considerable influence on the humanities curricula in engineering schools over the country. Many of the colleges have added humanities, provided for more electives, or otherwise broadened the liberal training given to engineers. However, several colleges have not been able to make adjustments to provide for more humanistic courses. Besides, the impact of specialized army training courses during the war may leave its mark on technical education for many years in the post-war period.

Following Dr. Burdell's paper came a series of short talks by various members of the English faculty of Illinois Institute of Technology, under the general leadership of Dr. Walter Hendricks, head of the department.

First in the series was that of Dr. S. I. Hayakawa, whose research and writings in semantics have attracted international attention. Dr. Hayakawa pointed out that semantics teaches the proper responses to separate words, but does not teach when *not* to respond; for example, correct English is always looked upon as an affectation, while correct mathematics is regarded as respectable and necessary. In semantics, the primary consideration is communication, while the techniques are only secondary. Many current habits of excess verbiage are based on early conceptions that mere wordiness is good.

The next speaker was Dr. M. P. Binyon, who complained that fine arts courses are usually limited to the arts or art appreciation, and have little time for language refinement. On the other hand, he believes, any program of liberal arts studies should affect the college as much as it does the student.

Dr. F. R. White discussed methods of presenting humanities to technical students, pointing out that technical schools are fortunate in the absence of tradition in such teaching, but are able to make use of scientific methods of logical evidence and tenable hypotheses. It must be remembered that logic is *in* science, not over or under it.

Dr. S. B. Meech continued the discussion of teaching methods by indicating some of his own ways of securing interest in the study of Shakespeare. His method centers about the Socratic style of questions and answers, with a maximum of individual interpretation from each student. Interest is heightened by much additional reading and drawing of comparisons between Shakespeare's age and modern times.

In summary, Dr. Hendricks reminded the conference that the technical school has come of age. Both students and the faculty are better selected than formerly, and both the personnel and the curricula are under especial attention, because of wartime emphasis on technical training. The aim of humanities training in technical schools should be to integrate rather than to separate human knowledge, and to enable graduates to express themselves rather than to pose as language specialists.

The next paper was that of Dr. J. H. Rushton, Technical Aide in the National Defense Research Committee, whose study was based upon the quality of reports sent to his office from researchers all over the country. Dr. Rushton admitted that most of his wide travel is caused by poor reports which give inaccurate or inadequate information. All of these weaknesses are complicated by the secrecy which has to be maintained in wartime. The speaker used several excerpts as illustrations of the tendency toward excess wording and vague sentence structure. He said that professional engineers frequently show the same tendency as students toward hedging and evasion, and general fear of writing.

Chairman Vaughan called a brief recess, after which was presented the final paper of the conference. It was given by Dr. R. L. Shurter of Case School of Applied Science, and dealt with the humanities in engineering colleges after the war. The speaker believes that at the end of hostilities, liberal arts courses of all kinds will be subjected to rigorous reëxamination; that many changes in education will follow the current emphasis on technical training; that the colleges will be flooded by students whose work has been interrupted by the war; and that the general scheme of progress—more time to do more better—will continue despite the static desires of faculty and alumni. Among the matters of unfinished business before English teachers at that time will be the problems of training of teachers for English in engineering schools; of organization of departments of humanities in engineering schools; of exchange professorships and other means of attracting competent men into such departments; of time to be allotted to the teaching of humanities; and of clear-cut objectives for humanistic courses.

Miss Granville Meixell, librarian of Columbia University, gave a progress report on the study she is undertaking of the libraries in engineering schools throughout the country.

Chairman Vaughan appointed a nominating committee which will report by mail later in the year. On the committee he placed H. L. Creek (Purdue), Chairman; W. S. Lynch (Cooper Union); F. H. Gertz (Pratt); and Paul V. Thompson (University of Colorado).

HOMER H. NUGENT, *Secretary*
ALVIN M. FOUNTAIN, *Acting*

The Importance of the Humanities in an Engineering Education

By GANO DUNN
President, The J. G. White Engineering Corp.

If an engineer's training neglects the great human mirrors of history and languages, particularly his own language; if his mind and heart are not sensible to the great social forces of his day and of his community; if he but feebly develops the subtle qualities of character that make for personality, his career as an engineer is limited, no matter how much science he may know.

I believe this more firmly now than when I first said it, in a commencement address a number of years ago.

In the meantime, as the engineering profession has developed, the center of education for engineers has been shifting more toward the humanities, and several of our leading engineering schools have established Departments of Humanities.

In earlier days, humanistic studies were considered not only to detract from the education of a technological specialist on account of the time diverted to a useless purpose, but to unsettle the mind of such a student through their lack of precision and the vagueness of their terms. But these considerations have long been thrown overboard, and in their place has come a realization that the study of history and of languages contributes to the development of the mind of a specialist, even as mathematics does to the mind of almost everybody else.

On these counts, even where intense technological specialization is intended, it is recognized that that very object will be better achieved by broader training.

There are other considerations that bear upon these factors. Not all men with an engineering education take up the practice of engineering; many are drawn off into the field of organization, and into other fields where the engineering method of approach to problems, and the engineering point of view, introduce fermenting leven into the processes of industrial business procedure.

Partly for this, and for other reasons, engineering has become the cornerstone of industry, and the function of management has fallen very largely to the engineer. In the field of management, which involves the play of the human spirit at its best and at its worst; and particularly in labor relations, where generosity, loyalty and independence are manifest, as well as passion, ignorance and vanity, the engineer's capacity for organization, leadership and sympathy with human problems has rare opportunities.

For all these reasons and in the technical as well as in broader fields, the engineer whose training has been

solely technical, is at a loss in competing with one whose training has been broader. He is at a loss because he is less able to make his views prevail, less able to persuade and to contend.

It is a satisfaction to see that the Committee on Aims and Scopes of Engineering Education has declared that, along with the scientific-technical stem of an engineer's education, should go an equally important humanistic-social one, and that included in its aims should be understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development; and that also should be included acquaintance with some of the great masterpieces of literature and art, and an understanding of their setting in and influence upon civilization.

Necrology

William Griswold Smith, former professor of engineering at Northwestern University, died December 25, 1943, of a heart attack suffered while on a Christmas visit to his daughter, Mrs. K. Van Ginkel of Pacakanack Lake, N. J. He was born in Toledo, Ohio, on July 18, 1870.

After two years at Yale, 1887–89, Professor Smith entered Cornell, where he received his degree of Mechanical Engineering in 1892. Before starting his long teaching career he spent several years in bicycle manufacturing, and then, in 1902, joined the faculty of the University of North Dakota, where he remained, 1902–04.

From 1905 to 1920 Professor Smith was an associate professor of engineering at the Armour Institute, Chicago, now the Illinois Institute of Technology. From 1920 until his retirement, nineteen years later, as professor emeritus, he filled the chair of engineering at Northwestern University.

During the present war period he returned to active teaching, first as a special lecturer at the Defense Training Institute, New York, from 1941 until last June, and since then, until his death, he had been in charge of engineering instruction at the Naval Reserve Unit at Franklin and Marshall College, Lancaster, Pa.

Professor Smith was the author of "Practical Descriptive Geometry," "Engineering Kinematics" and "Engineering Draughting." He was a member of the University Club of New York, the Delta Kappa Epsilon and Sigma Xi fraternities.